MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY & PHILOSOPHICAL SOCIETY

FOURTH SERIES

SEVENTH VOLUME

MANCHESTER
36 GEORGE STREET

1893

NOTE.

The authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 4th, 1892.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Reference was made to the deaths of three of the members of the Society, Dr. CARL SCHORLEMMER, F.R.S., Dr. J. E. MORGAN, and the Rev. CANON LLOYD, since the previous meeting of the Society.

Mr. W. E. HOYLE, M.A., exhibited a specimen of *Callichthys asper*, remarkable for its resemblance in the arrangement of the scales to the ganoid fishes of the coal measures ; and also specimens of *Scopelus antarcticus* and *Argyropelecus hemigymnus*, deep sea fishes, the former from a depth of 1,950 fathoms, and called attention to the phosphorescent organs of these species, the structure of which has been fully described by Dr. Von Lendenfeld, in an appendix to Dr. Gunther's report on the deep-sea fishes of the "Challenger" Expedition.

Mr. W. THOMSON referred to a case of electric shock received by Mr. Joseph Collier, F.R.C.S., from rocks in the Austrian Tyrol, and Dr. SCHUSTER remarked that the phenomena of such rock discharges had not been thoroughly investigated, and that records of such incidents would be valuable.

Professor OSBORNE REYNOLDS described a case of "pitting" in the tubes of a boiler at the Owens College. After being safely tested by a cold-water pressure of 300lb., one of the rust-pits gave way a few days later under a steam pressure of only 100lb. Beneath the crust of rust a black deposit was observed. A discussion as to whether this was a deposit of carbon from the iron, or black magnetic oxide, ensued. A noticeable fact was that the "pits" were most numerous at the smoke-box and not at the furnace end, and that there (at the cooler end) the lesion occurred.

Mr. F. J. FARADAY communicated a paper by Mr. FREDERICK HOVENDEN on "The Study of Motes in Air," in which the following experiment was described :—

"Take a shallow glass trough, having a depth from back to front of about ¼ inch. Fill it with tobacco smoke ; this will soon diffuse and the trough will appear filled with fog, that is, the contained air will be charged with motes. Cut a piece of cork and plug the mouth of the trough with it, in order to prevent the escape of the motes and the disturbance of air currents. Now, observe these motes by means of the microscope, using the ½ inch objective and a parabolic condenser. Illuminate with a strong light—sunlight, electric-light, or the oxy-hydrogen light. I have found either of these lights to answer very well. The individual motes will be seen, strongly illuminated, while the air-atoms—the gases between the motes—are apparently invisible. The motes stand away from each other as if they were separated by repulsion, or by something which is invisible existing between them and separating them. While the motes are thus divided each individual is in a state of constant and intense vibration, a sort of shivering or trembling of the mote *per se.* Besides this, each mote appears as if it had a pair of wing-like appendages. The motes are very small, and appear of equal dimensions. When any two motes seem to approach each other, this arises from the fact that they get behind each other, which is proved by the motes getting out of focus. No one can see this experiment without being struck with its beauty and its remarkable character. What are those wing-like appendages? I think they have nothing to do with the motes, and I do not think they are optical illusions."

A discussion ensued, in which Professor SCHUSTER, Professor REYNOLDS, Dr. G. H. BAILEY, Mr. W. THOMSON, and others, took part; and eventually it was resolved to adjourn the debate in order that the experiment might be tested.

Ordinary Meeting, October 18th, 1892.

Professor ARTHUR SCHUSTER, Ph.D., F.R.S., F.R.A.S., President, in the chair.

The thanks of the members were voted to the donors of the books upon the table.

The Society's EDITOR exhibited a specimen copy of the memorial volume on the life and work of Dr. JAMES PRESCOTT JOULE, written by Professor OSBORNE REYNOLDS at the request of the Council, and forming Vol. VI. of the Fourth Series of the *Memoirs and Proceedings*, and it was moved by Dr. BOTTOMLEY, seconded by Mr. CHARLES BAILEY, and resolved,

"That the thanks of the Society be given to Dr. Reynolds on the completion of his laborious work for the Society, in writing the *Memoir of Dr. James Prescott Joule*."

Dr. REYNOLDS briefly acknowledged the resolution, and expressed his sense of indebtedness to various members for assistance in collecting facts, in superintending the engraving of the frontispiece, and in the revision of the proofs.

Mr. W. THOMSON, F.R.S. Ed., gave an account of an attempt to repeat the experiment described in a paper by Mr. HOVENDEN, read at the previous meeting, showing "Brownian" movements of the particles of tobacco smoke when seen under the microscope. Mr. THOMSON said that he had tried the experiment by putting tobacco smoke in a test tube and also in a "live" cell box. At first he saw nothing but fog, but on keeping the eye steadily on the fog, he saw bright particles rushing violently about in all directions. He saw nothing of the nature of wings to the motes, and he was under the impression that what he saw was an optical illusion. The appearance he mentioned was produced most distinctly when the fog had nearly disappeared and when the eye had become somewhat fatigued by being steadily fixed on the same point, and when a comparatively low power objective was used. The illusion (if illusion it was) was less easily observed when the higher magnifying powers were employed.

Mr. R. F. GWYTHER, M.A., mentioned that Mr. W. E. HOYLE, M.A., and he had attempted to repeat Mr. HOVENDEN'S experiment. Examining the smoke by transmitted light, they had not been able to distinguish the phenomena described.

Mr. JOSEPH COLLIER, F.R.C.S., introduced by Mr. WILLIAM THOMSON, F.R.S. Ed., gave a detailed account of his personal experiences of an electric shock from a rock discharge when descending in August from one of the peaks of the Tyrol. The shock passed through the left arm, with which he was clinging to the rock, semi-paralysing it for a time, and burnt a hole through the stocking on the left foot. In the discussion which ensued, his escape from more serious consequences was attributed to the fact that he was drenched with rain at the time, the only portion of his clothing which had escaped wetting being the stocking, which was charred. The curious electric phenomenon known as the "singing" of the ice-axes, was very observable during the excursion.

Mr. J. C. MELVILL, M.A., F.L.S., read a paper on a specimen of *Trachelium cœruleum*, recently found by Mr. A. B. Brown, in Guernsey (the first discovery of the plant in the British region).

Mr. MELVILL also read the following note: "On a Monstrous Flowering Form of *Ranunculus bullatus* (L.) from Sicily":—

"My friends, Miss C. Birley and Miss Copland, collected at the beginning of this year (1892), amongst the ruins of the temple at Taormina, S. of Messina, Sicily, a form of the well-known *Ranunculus bullatus* (L.), in which the petals were turned in great measure to small stalked leaves, the veining of which was similar to that of the petals. Sepals, stamens, and receptacles, so far as could be judged by the dried specimens, were almost, or quite, normal. As surmised by Mr. Charles Bailey, on examination of the flowers, the petals seem to have a tendency to fl. plen.:—and these monstrous floral stalked leaves are as many as fifteen or sixteen in number. In only one case the yellow petals were seen as usual. Specimens of the usual form of *R. bullatus* (L.) from Spain, Corsica, Sardinia, and Algeria, are exhibited for comparison. I do not know another instance in which a member of the genus *Ranunculus* has afforded a similar phenomenon, though some species, especially *aconitifolius*, *repens*, and *acris*, show a great disposition to produce double flowers—more frequently in cultivation, but occasionally in a wild state. A form of *Trifolium repens* (L.) which I found recently in my field at Prestwich, with the petals turned to a coronal of small long-stalked trifoliate leaves, is the nearest approach to a similar instance that has come under my own observation."

On the Occurrence of Trachelium cœruleum (Linn.) in Guernsey. By James Cosmo Melvill, M.A., F.L.S.

(*Received October 18th, 1892*).

Trachelium, a genus of which the derivation is disputed,* was established by Linnæus from a somewhat aberrant form of the order *Campanulaceæ*, in which the flowers were small and corymbose, and the style unduly exserted; the species of this genus are all natives of the Mediterranean region of Europe, Asia, and Northern Africa, no one species extending in range over the whole area.

The type *T. cœruleum* (L.) is by far the best known of all the species, and it may be interesting to record its occurrence, for the first time, in one of a group of islands, which, though geographically French, have so long belonged to the British Crown that their botanical productions find a place in our native flora.

In the early part of September I received five specimens of this handsome plant from my friend Mr. Archibald Buchanan Brown, who has been resident in Guernsey since 1874-75. He has known this plant to have existed in the same profusion as it does at present for fully sixteen years, but, till now, imagined it was a colour variety (with blue flowers) of *Centranthus ruber* (DC.), the red valerian, and this assumption was strengthened by the fact that most of the specimens grew out of reach, and, therefore, the serrations on the leaves were not discernible. It may not be

*Note.—Derivation of this word either is τράχὺς, rough, from the roughness of the leaves, or from the rocky habitat, or τράχηλος, the throat. Throatwort, so-called either from its supposed efficacy, in common with certain species of *Campanula*, in diseases of the larynx: or, perhaps, in allusion to the lengthened tube or 'throat' of the corolla.

well to give the locality too precisely; but the plant is abundant on the outskirts of St. Peter's Port, in one or two contiguous places on old and somewhat ruinous walls of considerable height. Mr. Buchanan Brown counted one hundred and fifty blooms, at least, on August 16th last.

Doubtless the plant is an established introduction, but when and by whom is never likely to be solved. Old walls and ruins seem to be the favourite habitat of this plant, wherever found.

The Rev. R. P. Murray, from whom I received specimens collected in 1888 near Oporto, Portugal, writes me that it grew plentifully *on walls* by the River Douro, opposite Oporto, and that he saw it nowhere else, but was told that it grew on rocks about a mile further away.

T. cæruleum is restricted, according to Nyman, to the following countries:—

Lusit. bor. (introd.?). Hispania merid. orient. Italia merid.; Sicilia (Palermo); and it likewise occurs on the Mediterranean coasts of western North Africa, in Algeria abundantly (Bourgeau, Jamin, Munby, &c.), and Morocco (Ball).

It does not appear in the more eastern portion of Mediterranean Europe or Africa, and is not mentioned in Boissier's *Flora Orientalis* (Vol. III., p. 961 sqq.), the species *Jacquini* (Sieb.), *Rumelicum* (Hampe), *tubulosum* (Boiss.), *asperuloides* (Orph.), and *myrtifolium* (Boiss.) taking its place.

Five species are found, according to Nyman, (Consp., *Fl. Eur.*, p. 485) in Europe proper, viz.: *T. cæruleum* (L.), *lanceolatum* (Guss.) confined to Sicily, *Rumelicum* (Hampe), *Jacquini* (Boiss.), and *asperuloides* (Boiss. and Orph.), this latter peculiar to M. Chelmos in the Peloponnese.

Morocco possesses, besides *T. cæruleum*, one endemic species, *angustifolium* (Schousb.), of peculiar habit (*c.f.*, Spec. Flor. Marocc., in *Journ. Linn. Soc.*, xvi., pp. 555, 556), by John Ball.

Algeria contains only *T. cæruleum*, where it is very abundant.

Eight species of this genus, therefore, exist in all, members of the Mediterranean region, either E. or W., but, as already observed, no one species extending throughout the entire area.

Specimens of *T. cæruleum* (L.) are in either Mr. Charles Bailey's herbarium, or mine, or both, from the following localities. And here I must take the opportunity of sincerely thanking Mr. Bailey for the copious notes and quotations that accompanied his list as given below.

(i.) SPAIN : Andalusia :—

Sierra de Palma, près Algeciras. Rochers humides et ombragés. Rare - -	29 Juillet 1887.	E. Reverchon.
Sierra de Palma, Andalusia. Rochers humides et ombragés. Rare - -	29 Juin 1887.	E. Reverchon.
(Issued as No. 1753 in *Flora selecta exsiccata*, publié par. Ch. Magnier.)		
Cartama, Andalusia. Rochers humides.	8 Juillet 1888.	E. Reverchon.
Ronda, Andalusia. Sur les rochers humides et calcaires - - - -	9 Juillet 1889.	E. Reverchon.
Ronda, dans les grottes dans la vallée des Oliviers - - - - -	17 Juin 1851.	E. Bourgeau.
Grazalema, Andalusia. Lieux rocheux humides et ombragés - - -	26 Juin 1890.	E. Reverchon.
Jaën, Andalusia. Prope pagum Segura, ad rivulorum margines. Sol. calcar. 1000—1200^{m} o.m. - - - -	Juli 1890.	Porta & Rigo.
(Issued as No. 350, Porta et Rigo *Iter II. Hispanicum 1890.*)		
Granada, Andalusia - - - -	June, 1851.	John Ball.
Murcia, dans les murs de la Rue de la Nova. Bourgeau, Pl. d'Espagne 1855. No. 2305. - - - - -	30 Juin 1855.	Dr. Guirao.

(ii.) PORTUGAL :—

Old walls near Oporto - - - -	27 May 1888.	R. P. Murray.

(iii.) ITALY : Campania :—

Ad muros pr. Sorrento (south of Naples)	July, 1889.	H. Groves.
(Issued in Dr. C. Bænitz, *Herbarium Europæum.*)		
Parco di Caserta (north of Naples) -	7 Augt. 1875.	Com. A. G. Waters.

Calabria :—

Loc. irrigatis et arid calcareum torrentium circa Corregliano et Castrovillari 2-300^{m} - - - - - - - 25 Junio 1877. Huter, Porta & Rigo.
(Issued as No. 360, Huter, Porta et Rigo *ex itere italico III.*)
(Issued in Dr. C. Bænitz, *Herbarium Europæum.*)

Sicily :—

Ad muros humidos, Palermo - - Augt. 1882. M. Lo Jacono.
(Issued as No. 510, *Plantæ Siculæ rariores*, Lo Jacono.)

Ad muros in humentibus, Palermo - June . Todaro.
(Issued in *Todaro Flora Sicula Exiccata.*)

Palermo, ad muros in humentibus - July, 1890. Dr. H. Ross.
(Issued in Dr. C. Bænitz, *Herbarium Europæum.*)

Ad muros humidos prope Panormum - 25 July, 1855. Huet de Pavillon.

(iv.) **ALGERIA** :—

Oran. Rochers maritimes - - - 18 Juillet 1881. O. Debeaux.

Aqueducs romains à Medeah *Plantes d'Algérie.* No. 56 - - - - Juin 1850. P. Jamin.

Rochers humides à Hadjar Roum à l'est de Tiemcen. *Plantes d'Algérie.* No. 77 23 Juin 1856. E. Bourgeau.

In Battandier et Trabut's *Flore de l'Algérie*, Fasc. III., p. 570, it is marked with CCC=very common. "Lieux frais et ombreux du Tell. Espagne, Italie."

In Filippo Parlatore's *Flora Italiana, continuata da Teodoro Caruel*, Vol. VIII., p. 144, the geographical distribution is given as "Nasce inoltre in Ispagna, ed in Barberia," and on page 146, "In Toscana ed in Liguria il *Trachelium cœruleum* e da considerarsi come naturalizzato (v. Cand. geogr. bot. 1, p. 125). E cosa singolare come questa pianta mentisca l'aspetto di una Valerianacea." The Italian stations for it are given :—

Sicily : Messina, Palermo, Avola.

Calabria : Grotteria, Pozzano, Stilo, Tropea, Briatico, Castrovillari (Huter, Porta et Rigo !).

Campania : Portici, Caserta.

Lazio : Rome, in many localities, especially on the walls of the city.

Tuscany : Lucchi, Pozzuolo.

Liguria : Genoa.

In Willkomm & Lange's *Prodromus Floræ Hispanicæ*, Vol. II., p. 298, the Spanish localities are given for it as :—"Ad rupes et parietes humidas umbrosas aliisque in locis umbrosis regionis inferioris et montanæ Hispaniæ oriental. et australis."

Catalaunia : Ruins of the monastery Scala Dei, Mousent.

Aragon : Peñarroya ad la Cenia.

Valentia : In deserto la Murta. Enguera.

Murcia : La Noria.

Granada : Malacitano, Coin, Alhaurin, Granada, &c., on the walls of the Alhambra.

Sierra Nevada : Guejar, Cordova.

Hab. Quoque in Ital med. et austr. in Africa boreali.

Ordinary Meeting, November 1st, 1892.

Professor ARTHUR SCHUSTER, Ph.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Reference was made to the death of Dr. A. W. HOFMAN, F.R.S., &c., &c., who was elected an honorary member of the Society in 1866.

A conversation on the possible reasons why the temperature of the blood does not rise in hot countries above the normal temperature took place, the subject being introduced by the PRESIDENT. It was admitted that the phenomenon had not yet been adequately explained.

General Meeting, November 15th, 1892.

Professor ARTHUR SCHUSTER, Ph.D., F.R.S., F.R.A.S., President, in the Chair.

Mr. W. G. GROVES, Brewer, The Larches, Alderley Edge; Mr. F. E. WEISS, Professor of Botany, The Owens College, Manchester; and Mr. W. H. PERKIN, Junr., Ph.D., F.R.S., Professor of Organic Chemistry, The Owens College, Manchester, were elected ordinary members of the Society.

Ordinary Meeting, November 15th, 1892.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

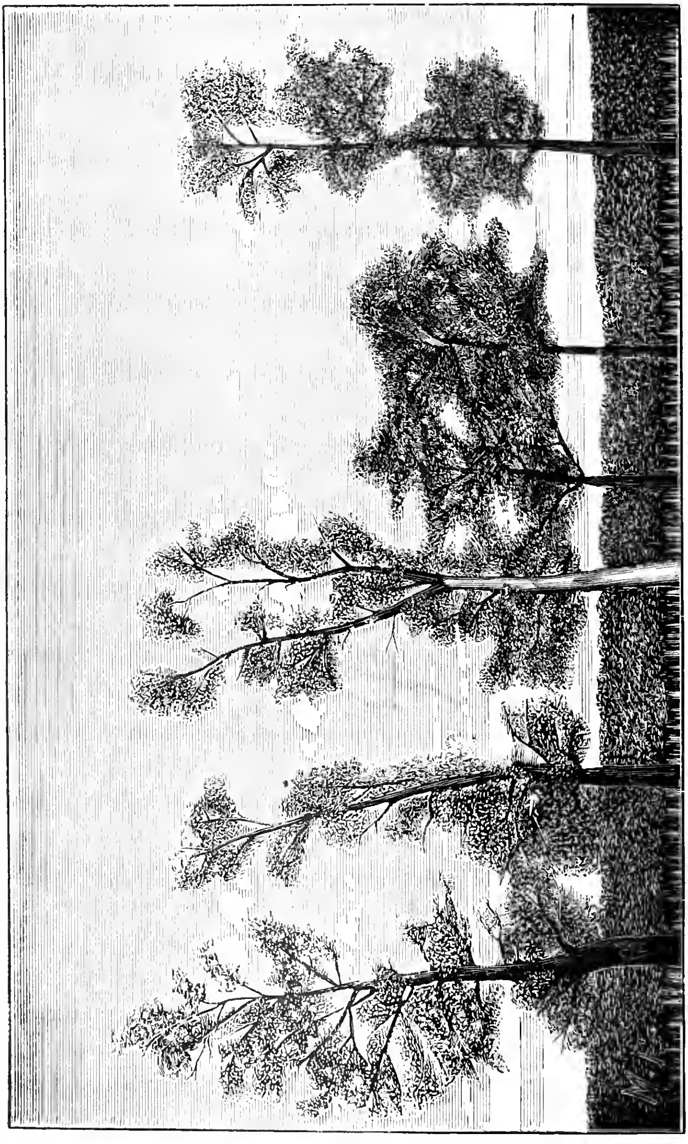
The thanks of the members were voted to the donors of the books upon the table.

The PRESIDENT (Dr. SCHUSTER) read a letter from Mr. WILLIAM THOMSON, F.R.S.Ed., accompanying a portrait of the late Joseph Baxendell, F.R.S.—for twenty-five years one of the honorary secretaries of the Society—offered by Mr. Brothers for the sum of twelve guineas. Mr. THOMSON proposed to head a subscription list for the purchase of the portrait.

Mr. CHARLES BAILEY, F.L.S., presented, on behalf of the Rev. HENRY SHAW, of Urmston, a syllabus of lectures on chemistry delivered in Manchester in 1783 by Mr. Thomas Henry, F.R.S., one of the founders and first secretaries of the Society.

With reference to the memorials of deceased members possessed by the Society, Dr. BOTTOMLEY and Mr. FRANCIS NICHOLSON, F.Z.S., drew attention to the desirableness of increasing the collection of portraits, and it was mentioned that the Manchester Royal Infirmary Board had formerly, and should still have, in its possession portraits of various early members of the Society, including those of Mr. Charles White, F.R.S., and Mr. James Massey, the latter by Tate.

Mr. F. J. FARADAY, F.L.S., exhibited a sketch of a row of trees situated in the field path from Slade Lane to Ladybarn Road, Fallowfield, parallel with the new railway line from Levenshulme to Fallowfield, one of which was struck by lightning on the afternoon of July 2nd, 1891.



The sketch was taken immediately after the event by Miss M. Faraday. The tall trees shown in the sketch (see opposite page) are balsam poplars, the two smaller ones being common ash trees. The relative heights of the trees are correctly indicated in the sketch. The direction of the line of trees is roughly from west to east, the solitary poplar beyond the ash trees on the right hand side of the sketch being the west end. A lady seated at the dining-room window of Ramsay Lodge, facing the east end of the line of trees, the direction of the window being at a right angle to the line of the trees, observed the flash coming towards her as a tube of blue flame. The tree struck was the third from the east end, and the only damage done to it was the stripping of the bark, from a point where the trunk forks, to the ground, as shown by the white portion of the trunk in the sketch. This stripping apparently began at a point under the stump of a broken branch projecting from the side towards the ash trees, and it curved round to the side of the tree as seen in the sketch, increasing in width to the extent of the full diameter of the trunk as it approached the ground. Fragments of the bark were strewed about the ground, at the foot of the tree, but there was no appearance of injury to the foliage or any stripping of the leaves. A heavy rain storm preceded and accompanied the flash, and the foliage was probably thoroughly drenched, the lower part of the trunk being, however, protected by the leaves, while the point where the stripping of the bark began was further protected by the projecting fragment of branch. Mr. Faraday pointed out that the line of foliage of the ash trees was continuous with that of the tree which was struck opposite the point where the stripping of the bark began, the branches interlacing; while at the east side of the tree there was a clear gap between its foliage and that of the next tree on that side. He suggested that the charge might be carried through the wet foliage of the stricken poplar and ash trees along the (externally) dryer portion of the trunk to the ground from the angle where the projecting branch protected the bark of the trunk from the moisture. He added that he had been led to exhibit the sketch and communicate an account of the occurrence in consequence of Professor Schuster's remark at the previous meeting in connection with Mr. Collier's account of the electric shock received by him in the Tyrol, on the desirableness of records of lightning strokes being preserved with a view to the elucidation of these phenomena.

A discussion ensued, during which reference was made to previous observations which seemed to indicate differences in the liability of different species of trees to lightning strokes; and the PRESIDENT (Dr. SCHUSTER) repeated his opinion as to the probable utility of careful records of such occurrences, and expressed a hope that the sketch would be reproduced in the *Memoirs and Proceedings*.

A paper on "The Marine Molluscan Fauna of Bombay," by Mr. J. C. MELVILL, M.A., F.L.S., and Mr. A. ABERCROMBIE, was read by the former, and Mr. ABERCROMBIE exhibited a collection of shells gathered by him on the Bombay coast. During the discussion which ensued, the extraordinary richness and variety of the collection made by Mr. Abercrombie, including many species new to science, were commented on.

The Marine Mollusca of Bombay. By James Cosmo Melvill, M.A., F.L.S., and Alexander Abercrombie.

(*Received November 15th, 1892.*)

(*a*) *General Remarks.*

The shores of the coast in the vicinity of Bombay are of trap rock, with occasional sandy bays. Running behind the coast-line are immense tracts of low-lying land (at times covered by the sea), or tidal creeks, with slimy mud banks, and mangrove bushes. During the rainy season, the fall in which averages some 80 inches, these creeks and swamps become the mouths of rivers, and for many months the water contained therein must be very brackish. These bring down and pour into the sea a nearly perpetual stream of mud-laden water, and the ocean for some distance around Bombay is, therefore, rarely clear enough to enable one to see down into its depths, even a few feet.

In consequence of the rocky nature of the coast, and, not least, the mud, dredging does not seem to answer, and the collector must, therefore, be satisfied with what can be found between tide marks, and, happily, the expanse of shore at the lowest spring tides laid bare is considerable, and it is on these occasions that the rare cowries, *e.g.*, *C. Lamarckii*, *lentiginosa*, and *ocellata*, are collected in fine living condition.

Both univalves and bivalves, the latter especially, are largely collected by the fisherman class for edible purposes.

The common oyster, for instance, (*O. crenulifera*), clustered in masses on rocks left bare at half-tide, is broken open by means of a small hammer or stone, aud the animal extracted with ease, and as regards the large species (*O. bicolor* and its varieties) the markets are regularly supplied with them. *Purpura carinifera* and *Cantharus spiralis* are regularly gathered off the stones and rocky beach, and enormous quantities of the shells of such species as *Circe divaricata* and *Arca granosa*, are often found in the vicinity of the dwellings of those who live by the sea shore.

At all the low tides women and children are employed, standing almost up to their knees in black slimy mud, digging up with their hands *Chione pinguis*, a very abundant species, allied to the clam of the United States (*M. mercenaria*) ; and, in addition to the species just mentioned, *Chione radiata*, the handsome *Tapes textrix*, and the curious brachiopod *Lingula hians*, all found in similar places, are often offered for sale, as edible species, in the markets.

For the collector who is satisfied with specimens, often, it is true, in dead condition, but mostly of fresh appearance and lustre, there are few of the Bombay species that cannot be obtained in one or other of the two sandy bays in the island, where a rich harvest may be said to be always awaiting him. Most of the smaller species, *e.g.*, *Pleurotomæ*, *Rissoæ*, *Pyramidellidæ*, and the like, have been obtained by sifting shell-sand obtained in abundance at low water. During the monsoon season, especially, many rare specimens may be obtained which are never, or at all events seldom, seen otherwise.

The collection of Marine Shells now to be catalogued has been formed almost entirely in the Island of Bombay, and comprises about 320 species. A few have been obtained from districts lying immediately north, and from Ratnagiri, 150 miles to the south, and where this is the case, the locality is given in the list appended.

The Mollusca of Bombay are specially interesting in a two-fold way.

Firstly, because of the wide range westward that many species, known to have their metropolis in the Philippine Islands, or even in Japan and S. E. Australia, show, when found to occur here; and, secondly, because several interesting forms are endemic, or nearly so.

Such are—

Cyllene fuscata (Ad.),
Zizyphinus scobinatus (Ad.),
Fairbankia Bombayana (W. Blanf.),
Nerita oryzarum (Récluz),
Conus lentiginosus (Reeve),

and, so far as is known at present, the new species to be described at the present opportunity.

A very few would appear to be outlying forms, almost, if not quite, identical with British or Mediterranean species, *e.g* :

Calyptræa Sinensis (L.) var.
Arca lactea (L.) var.
Cylichna cylindracea (Pennant).

Amongst the specimens found on the open sea shore are the following brackish or fresh water shells. These, for the most part, we do not include in our Catalogue, since they should be classed more with the Fluviatile Mollusca than with Marine, as

Neritina crepidularia (Lam.).
Potamides (*Tympanotonos*) *fluviatilis* (P. & M.).
Telescopium fuscum (Schum.).
Lymnæa pinguis (Dohrn).
Melania tuberculata (Moll.).
Auricula Judæ (Linn.).
Cassidula nucleus (Mart.).
Ampullaria nux (Reeve).
 „ *dolioides* (Reeve).

Of these, the two first mentioned are especially abundant. The following twenty shells, described as more or less endemic in Bombay, we have not, so far, been able to find amongst our mass of material collected. The majority of these have been catalogued by Mr. G. Nevill, as being in the collection of the Indian Museum, Calcutta, a catalogue of which, unfortunately, only two parts have been issued, the first of which is devoted to the Terrestrial and Fluviatile species:

Mangilia (*Cythara*), *gradata* (Nevill).
Ringicula minuta allied to *propinquans* (Hinds).
Marginella inconspicua (Nevill).
Stenothyra minima (Sowb.).
Rissoina ambigua (Gould).
„ *plicatula* (Gould).
„ (*Isseliella*) *abnormis* (G. Nevill).
Fenella pupoides (A. Ad.).
Onoba delicata (Philippi).
[This may be the Onoba sp. in our collection.]
Scaliola arenosa (A. Ad.).
Littorina carinifera (Menke).
Fossar (*Couthouyia*) *reticulatus* (A. Ad.).
„ „ *styliferinus* (G. Nevill).
„ „ *subreticulatus* (G. Nevill).
Conradia doliaris (A. Adams).
Diala sulcifera (A. Adams).
„ *macula* (Récluz).
Alaba Blanfordi (A. Adams).
Cerithium mamillatum (Rieso).
Clanculus sulcarius (Blanford).

On the other hand, we have thirty or more species, apparently undescribed, but which we are holding in reserve until fresh material can be obtained.

The Bombay shores are particularly rich in specimens of the following, which may be considered typical of the locality:—

Gasteropoda.		Pelecypoda.	
Conus mutabilis (Chem.)		*Placuna placenta* (Linn.).	C.
Pleurotoma crenularis (Lam.).		*Arca lactea* (Linn).	A.
,, *amicta* (Smith).		,, *bistrigata* (Dunker).	
Oliva nebulosa (Lam.).	K.C.	,, *granosa* (Lamk.).	
Cantharus spiralis (Gray).	K.	*Cardita antiquata* (Lamk.).	
Eburna spirata (Lam.).	K.C.	*Cardium coronatum* (Speng).	
Nassa ornata (Kiener).	C.	*Libitina vellicata* (Reeve).	K
,, *nodifera* (Powis).		*Meretrix morphina* (Lam.).	C.
Columbella terpsichore (Leathes)	K.C.P.	*Circe divaricata* (Chem.)	
Murex adustus (Lam.).		*Meroe solandri* (Gray).	K.
Ranella tuberculata (Brod.)	K.	*Venus imbricata* (Sowb.).	
Cerithium morus (Lam.)	P.	*Chione pinguis* (Hinds).	K.C.
Planaxis sulcatus (Bon.).	K.C.	,, *radiata* (Chem.).	C.
Turritella duplicata (Linn.).	K.	*Tapes Textrix* ,,	C.
Littorina malaccana (Phil.)		*Donax dysoni* (Desh.).	
Natica didyma (Bolten).	A.C.	*Solen truncatus* (Sowb.).	A.C.
,, *maculosa* (Lam.).		*Standella capillacea* (Desh.).	
,, *lineata* (Lam.).	C.	*Pholas bakeri* (Desh.).	K.
Nerita oryzarum (Recluz).		*Tellina edentula* (Spen.).	A.
Clanculus depictus (A. Ad.).	C.	,, *ala* (Hanley).	C.
Trochus radiatus (Gmelin).	A.	,, *sinuata* (Spen).	
Rotella vestiaria (Lam.).	C.P.	,, *truncata* (Jonas).	
Patella aster (Reeve).		,, *capsoides* (Lam).	
		Semele cordiformis (Sowb.).	

(*b*) *Comparison with other shores on the Western half (Arabian Sea) of the Indian Ocean.*

We have, as far as possible, compared this list with catalogues and descriptions of shells from

(I.) *Aden* [A.].
(II.) *Persian Gulf* [P.].
(III.) *Karachi* [K.].
(IV.) *Ceylon* [C.].

(I.) *Aden.*—In an interesting article by Mr. Edgar A. Smith (*Proc. Zool. Soc.*, 1891), we find only five species contained in our list, and these are all, as might be expected, of very wide distribution in Eastern Tropical Seas; indeed one, *Arca lactea*, we have already referred to as being a European shell, extending throughout the East to Japan; and of the *Tellinidæ* only one, *T. edentula*, occurs at Aden.

(II.) *Persian Gulf.*—This Fauna has been but very little studied, and we cannot discover more than three papers which have been published exclusively on the subject.

1. Issel, in 1865, gave to the world a list of shells found at Bunder-Abbas, and the Isle of Ormus, by G. Doria and Philippi, but only 17 species are included.*

2. Dr. E. von Martens in 1874 enumerated the Mollusca of Bushire, as found by M. Hausknecht, amounting to 49 in all, and to which a treatise is devoted.—*Ueber Vorderasiatische Conchylien*, Cassel, 1874.

3. Lastly, M. F. Houssay† explored the shores near Bender-Bouchir, on the East coast of the Persian Gulf, in 1884—1886, and Dr. P. Fischer has catalogued 33 species, of which the following are found also in Bombay.

Siphonaria Kurracheensis (Reeve).
Purpura carinifera (Lam.).
Cerithium morus (Lam.).
(but of the form *C. clypeomorus* (Jousseaume).
Potamides fluviatilis (P. & M.).
Umbonium vestiarium (L.).
Lucina fibula (Reeve).

(III.) *Karachi.*—We can find no very recent catalogue of shells from this port, but in Dr. P. Fischer's *Manual de Conchyliologie*, p. 160, a list is given, as having been formed by the late Col. Baker. Unfortunately, many are only generically, not specifically, alluded to, which renders identification not possible. We are, however, able to point to ten species common to both places, and this number will probably some day be very largely increased.

(IV.) *Ceylon.*—The lists of the Molluscan Fauna of Ceylon that we have compared with our Bombay catalogue are chiefly those of Sir J. Emerson Tennant (Ceylon, Vol. I.,

* Catalogo dei Molluschi raccolti dalla Missione Italiana in Persia (*Memoire della Reale Accademia delle Scienze di Torino*, série II., vol. 23, 1865).

† Vide *Journ. de Conch.*, 3rd Ser., Tome XXXI. pp. 222 sqq.

p. 235 sqq., 1859), which was supplied by Mr. Sylvanus Hanley, F.L.S., and one of the marine *Gasteropoda* only, by the late Mr. A. W. Langdon (*Journ. of Conch.*, Vol. I., p. 71 sqq., 1874). The principal contributors since those dates towards the elucidation of the Fauna have been Messrs. G. and H. Nevill, whose results have been mainly published in the *Journ. Asiatic Soc. Bengal.*

Mr. Hanley's catalogue is much fuller than that of Langdon, which latter does not include the *Pelecypoda.*

Of the 265 *Gasteropoda*, 32 occur in our Bombay list, and of the 130 *Pelecypoda*, 21.

Too much weight should not, however, be given to these proportionate figures, as in the Ceylon catalogue the smaller genera were hardly taken count of, and, naturally, this island being several degrees nearer the Equator than Bombay, a more varied selection of tropical forms is to be expected. For instance, 47 to 50 *Conus* are there reported, 26 *Cypræa*, 9 *Murex*, and 11 *Oliva.*

Considering that Bombay is one of the most cosmopolitan centres in the world, it seems somewhat strange that, as yet, no list of the Marine Mollusca has been issued. Such a list, we believe, was some years ago contemplated by the Rev. S. B. Fairbank, an American clergyman, who collected largely at this port, but we have been unable, unfortunately, to communicate with this gentleman. If we except such well-known names as Mr. W. T. Blanford, F.R.S., his brother, Mr. Henry F. Blanford, F.R.S., the late Dr. F. Stoliczka, and Mr. Geoffrey Nevill, late of the Indian Museum, Calcutta, we cannot find that any collector has turned his attention to these shores. And the same remarks would apply to almost the whole coast of Hindustan proper. Ceylon, the Andaman Islands, and the Mergui Archipelago off the coast of Tenasserim, have been more assiduously investigated, the latter by Dr. John Anderson, superintendent of the Indian Museum, Calcutta, and the results published two or three years ago in *Proc. Linn. Soc.*

Our best thanks are due to Mr. Edgar A. Smith, F.Z.S. of the Zoological Department, Mus. Brit., South Kensington, for his ever-ready help and assistance. To Mr. W. T. Blanford and Mr. Henry Blanford* we are also indebted for information and advice on several points, and also to Mr. R. D. Darbishire, of Manchester, for the loan of an interesting little collection of Bombay Shells found about five years ago by Mr. Herford.

The collections, a catalogue of which is now given, were formed by Mr. Alexander Abercrombie during the years 1888—1892.

(*c*) *Catalogue of Marine Mollusca of Bombay and immediate neighbourhood :—*

The sequence observed is altogether that of Dr. Paul Fischer's *Manuel de Conchyliologie.*

GASTEROPODA.

Fam. Siphonariidæ.

Siphonaria (Blvlle.).

S. Kurracheensis (Roe).

S. Basseinensis (Melvill), *sp. nov.*

The latter a little brown shell, pretty common amongst shingle.

Fam. Actaeonidæ.

Leucotina (A. Adams).

L. eximia Lischke.

* It is with unfeigned regret that we have to record the death of Mr. Henry Francis Blanford, F.R.S., which occurred at Folkestone on January 23rd, 1893, while these pages were under process of revision. Mr. Blanford will be remembered not only on account of his eminence as a student of Mollusca, especially those of India, but also as being for many years Meteorological Reporter to the Indian Government.

MYONIA (A. Adams).

M. amaena (Adams).

An extremely beautiful little shell, transparent, with fine transverse markings.

Fam. TORNATINIDÆ.

TORNATINA (A. Adams).

T. involuta (Nevill) allied to *sandwichensis* (Pease).

SAO (H. and A. Adams).

S. Pellyi (Smith).

Fam. SCAPHANDRIDÆ.

SMARAGDINELLA (H. & A. Ad.).

S. (*Glauconella*) *Andersoni* (Nevill), from Ratnagiri.

CYLICHNA (Loven).

C. cylindracea (Pennant).

Fam. BULLIDÆ.

HAMINEA (Leach).

H. galba (Pease).

Fairly common, but so extremely delicate that it is rarely found perfect.

Fam. APLUSTRIDÆ.

BULLINA (Ferrussac).

B. ziczac (Muhlfeld).

Of this beautiful little shell only a single specimen was found, and though widely distributed over the tropics, both of E. and W. Hemispheres, it seems common nowhere.

Fam. RINGICULIDÆ.

RINGICULA (Desh.).

R. propinquans (Hinds).

Common amongst shingle. Adult shells very massive for their size, and mouth much closed in by callosity of outer lip and columella. Young shell spirally and beautifully incisely lined, which disappears in the older shell. *R. apicata* (Nevill) seems allied.

Fam. TEREBRIDÆ.

TEREBRA (Adanson).

T. cinctella (Desh.).

Also in Mus. Brit., from Karachi.

ABRETIA (H. & A. Ad.).

A. tenera (Hinds).

This shell seems common in Ceylon.

Fam. CONIDÆ.

CONUS (Linn).

C. monachus (L.) var. *achatinus* (Chem.).

C. mutabilis (Chem.).

C. lentiginosus (Reeve).

C. piperatus (Reeve).

C. textile (Linn.).

C. insculptus (Kiener), only in young condition.

Mutabilis is the common species. *Monachus* and *lentiginosus* are frequently met with, the last-named belonging to the sub-genus *Leptoconus*, and being apparently endemic to Bombay.

Fam. PLEUROTOMIDÆ.

CLAVATULA (Lam.).

C. virginia (Bech.)

SURCULA (H. and A. Ad.).

S. javana (L.) = *nodifera* (Lam.).

S. fulminata (Kiener).

S. amicta (Smith) = *cincta* (Lam.).

DRILLIA (Gray).

D. Atkinsonii (Smith) = *crenularis* (Lamk.).

CLAVUS (Montfort).

C. sacra (Reeve).

C. crassa (Smith).

C. praeclara (Melvill) *sp. nov.*

MANGILIA (Risso).

M. fulvocincta (Nevill).

M. lucida (Smith).

M. fortistriata (Smith).
M. decipiens (Smith).
M. Fairbanki (Nevill).
M. perplexa (Nevill).
M. foraminata (Reeve).
M. (*Clathurella*) *tincta* (Reeve)=*lemniscata* (Nevill).
M. Armstrongi (Nevill) }
M. Smithii (Nevill) } these with doubt.
M. bicinctula (Nevill) }

D. atkinsonii is the common shell, and it seems impossible, satisfactorily, to separate our specimens from *crenularis* (Lam.), which has also been described as from Bombay. Young specimens are brownish with purple tinge, and differ a good deal from the massive appearance of the old shell. We should also not be surprised to find out that *crassa* (Smith) will turn out to be but another form of this species. *S. amicta* seems very common on the coast to the north of Bombay.

S. fulminata is a beautiful shell when in perfect condition. Lives in deep water, and occurs in Bombay Harbour in mud.

Of the *Mangiliæ fortistriata*, *decipiens*, and *foraminata* occur most frequently. *Tincta* is a beautiful little shell, easily known by the brown band at the suture.

The Nevill types being in the Calcutta Museum, it has been difficult to feel certain of the naming of some of our specimens.

Fam. CANCELLARIIDÆ.

CANCELLARIA (Lam.).

C. (*Trigonostoma*) *scalarina* (Lam.).
C. ,, *costifera* (Sowb.).

This family is not at all common, and it may be that these two species are but forms of one. All were found in one locality, washed up by heavy seas. They are deep water shells.

C. (*Merica*, H. and A. Ad.) *bifasciata* (Desh.)=*oblonga* (Sowb.).

Rare.

Fam. OLIVIDÆ.

OLIVA (Brug).

O. nebulosa (Lam.).

O. maura L., var. *B. sepulturalis* (Lam.).

OLIVELLA (Swainson).

O. nympha (Adams).

Nebulosa and its variety *intricata* (Marrat) are exceedingly common on sandy shores, but live specimens are not found.

Fam. HARPIDÆ.

HARPA (Lam.).

H. conoidalis (Lam.) appears in Mr. Herford's collection, but we have not found it.

Fam. MARGINELLIDÆ.

MARGINELLA (Lam.).

M. mazagonica (Melvill), *sp. nov.*

Very common in shingle.

Fam. MITRIDÆ.

MITRA (Lam.).

M. procissa (Reeve).

M. chinensis (Gray). A single worn specimen.

Specimens of this family are rare.

Fam. FASCIOLARIIDÆ.

FASCIOLARIA (Lam.).

F. trapezium (Lam.) from Ratnagiri.

Fam. TURBINELLIDÆ.

TURBINELLA (Lam.).

T. gravis (Dillwyn), *napus* (Lam.).

T. (*Myristica*, Swainson) *bucephala* (Lam.).

Fam. BUCCINIDÆ.

CYLLENE (Gray).

C. fuscata (A. Ad.).

TRITONIDEA (Swainson).

T. rubiginosa (Reeve).

(*Cantharus*) *spiralis* (Gray).

ENGINA (Gray).

E. zea (Melvill), *sp. nov.*

DIPSACCUS (Klein).

D. (*Eburna*) *spiratus* (Lam.).

NASSARIA (Link).

N. suturalis var. = *recurva* (Sowb.).

C. spiralis and *D. spiratus* are very common, the former on rocks, the latter in sand. *C. fuscata* may frequently be found at very low tides from its habit of exposing itself when left stranded. It apparently burrows in sand. In its normal form it appears to be a somewhat smooth-backed shell with marbled markings and white transverse lines filetted with brown. Some specimens, however, are longitudinally corrugate, and they do not appear to have the beautiful coloration just mentioned.

Fam. NASSIDÆ.

NASSA (Lam.).

N. (*Uzita*, H. & A. Ad.), *nodifera* (Powis).
ornata (Kiener).

Both very common on sand.

N. (*Arcularia*, Link.) *Thersites* (Brug.) from Ratnagiri.
lentiginosa (A. Ad.).

Very rare at Bombay.

N. (*Telasco*, H. and A. Ad.) *filosa* (Gray).
var. *picta* (Dunker).

Common on coast to North of Bombay.

N. (*Telasco*) *mucronata* (Ad.).

There appear to be one or two more species of *Nassa*, but specimens are worn and unnameable. Mr. F. P. Marrat, of the Liverpool Museum, has kindly examined most of our specimens.

BULLIA (Gray).

B. Mauritiana (Gray). Rare.

B. (*Leiodomus*, Swainson) *lineolata* (Wood) = *belangeri* (Kiener).

B. Malabarica (Hanley) also occurs, but we were not fortunate enough to secure specimens.

Fam. COLUMBELLIDÆ.

COLUMBELLA (Lam.).

C. scripta (Lam.).

C. (*anachis*, Ad.) *Terpsichore* (Leathes).

C. (*Mitrella*, Risso) *Marquesa* (Gaskoin).

C. „ (Risso) *Euterpe* (Melvill), *sp. nov.*

C. „ *flavilinea* (Melvill), *sp. nov.*

C. (*Seminella*, Pease) *atrata* (Gould).

C. „ *atomella* (Dudos).

C. Terpsichore and both the *Seminellæ* are common, and the latter are represented in the Mus. Brit. by specimens found by Mr. Craven, at Bombay.

Fam. MURICIDÆ.

MUREX (Linn.).

M. tribulus (Linn.)

M. (*Chicoreus*, Montfort), *adustus* (Lam.).

M. „ *maurus* (Brod.).

OCINEBRA (Gray).

O. Bombayana (Melvill) *sp. nov.*

UROSALPINX (Stimpson)

U. contracta (Reeve).

PURPURA (Brug.).

P. echinulata (Lam.).

P. bufo (Lam.).

P. carinifera (Lam.).

P. Rudolfi (Lam.) = *persica* (Linn.).

P. Tissoti (Petit).

P. hippocastanum (Lam.).

P. Blanfordi (Melvill) *sp. nov.*

P. (*Cuma*, Swainson), *sacellum* (Lam.).

RICINULA (Lam.).

R. (*Sistrum*, Mont.). *tuberculata* (De Blain).
Konkanensis (Melvill) *sp. nov.*
subnodulosa (Melvill) *sp. nov.*
xuthedra (Melvill) *sp. nov.*

CORALLIOPHILLA (H. and A. Ad.).

C. Jeffreysii (Smith).

M. adustus is pretty common amongst muddy stones. *P. bufo* and *P. Rudolfi* amongst boulders at low tides. *P. carinifera* very common on muddy rocks. *U. contracta* also common. There seem to be two forms, one with white bands crossing the ribs at the angle, the other nearly uniform in colour, generally red brown, but sometimes dull white. *P. sacellum*—the spire of this handsome shell bears some resemblance to a pagoda ; it is not uncommon in chinks of rocks at low tides. Young specimens light yellow. *S. tuberculatum*, a common and remarkably massive shell for its size.

Fam. TRITONIDÆ.

TRITON (Montfort).

T. pilearis (Linn.).

T. aquatilis (Reeve).

Both rare.

T. (*Linatella*, Gray), *cingulata* (Pfeiffer), from Ratnagiri.

RANELLA (Lam.).

R. (*Apollon*, Montf.), *tuberculata* (Brod.) = *olivator* (Mensch).

R. spinosa (Lam.).

R. subgranosa (Bk.).

R. tuberculata is the only common shell and frequents low tide rocks.

Fam. DOLIIDÆ.

DOLIUM (Lam.).

D. maculatum (Lam.).

Fairly common. A deep sea shell. Some specimens seem a little to approach *fimbriatum*, which after all may be only a variety.

PYRULA (Lam.).

P. ficus (Linn.), *Ficus laevigata* (Lam.).
Sycotopus ficus (Linn.).

Rare at Bombay.

Fam. CYPRAEIDÆ.

OVULA (Brug.).

O. pudica (Adams).
O. Trailii (Adams).
O. indica (Reeve).
O. (*Radius*, Mont.), *spelta* (Linn.).
None of the *ovulæ* are common.

CYPRÆA (Linn.).

C. arabica (Lam.) with var. *histrio* (Gmelin).
C. ocellata (Lam.).
C. Lamarckii (Gray) allied to *miliaris* (Gmelin).
C. pallida (Gray).
C. lentiginosa (Gray).
C. moneta (Linn.).
C. annulus (Linn.).

ERATO (Risso).

E. pellucida (Reeve).

C. arabica and *pallida* are the commonest under rocks and stones, but are rarely found except at very low tides. *Ocellata* and *Lamarckii* much less common, and latter seems to frequent muddy places or seaweedy rocks and stones. *Lentiginosa* is rather rare. *Moneta* and *annulus* are seldom found.

Fam. STROMBIDÆ.

STROMBUS (Linn).

S. gibberulus (Linn.).

PTEROCERA (Lam.).

P. lambis (Linn.).

ROSTELLARIA (Lam.).

R. curta (Sowb.).

The *Rostellaria* is fairly common, but never found alive, generally with a crab in possession, though a heavy tapering shell.

Fam. CERITHIIDÆ.

CERITHIUM (Adanson).

C. morus (Lam.).

C. rubus (Mertyn).

Morus is very common on half-tide rocks, and very variable in shape.

Cerithidea Bombayana (Sowb.), *Layardi* (A. Ad.), and also *Rhizoporarum* (A. Ad.) are all mentioned as from Bombay, but out of a great number of specimens of the family we have not been able to satisfactorily trace any but the two above named.

TRIFORIS (Desh.).

T. perversa (Linn.).

T. sp.

Perversa is a Mediterranean species, but our specimens appear to differ little from it.

CERITHIOPSIS (F. Han.)

C. (*Seila*, A. Ad.) *Bandorensis* (Melvill) *sp. nov.*

Fam. PLANAXIDÆ.

PLANAXIS (Lam.).

P. sulcatus (Born).

P. similis (Smith).

Sulcatus very common upon rocks which are only in reach of full tide.

Fam. VERMETIDÆ.

VERMETUS (Adams).

V. sp. One species uncertain, found amongst shingle.

Fam. TURRITELLIDÆ.

TURRITELLA (Lam.).

T. (*Zaria*) *duplicata* (Linn.).

Very common on all the shores. It may be that *T. cerea* (Reeve), *bacillum* (Kiene), also occurs, but as live full-grown specimens have not been found, it is a little uncertain.

Fam. LITORINIDÆ.

LITORINA (Ferussae).

L. (*Melaraphe*) *intermedia* (Phil.).

Young specimens only.

L. ventricosa (Phil.).

TECTARIUS (Val.).

T. Malaccanus (Phil.).

This last is very abundant, and lives high on the sun-heated rocks above the reach of all, excepting spray, or the highest spring tides. *L. ventricosa* is also very common, more to the south, and lives in similar positions.

Fam. FOSSARIDÆ.

FOSSARUS (Philippi).

F. tornatilis (Gould) = *stolickzanus* (Nevill).

F. fenestriatus (Adams).

F. trochlearis (Adams).

F. sp.

F. sp.

All very uncommon. As to the two (or three) unnamed species, we have left them for the present, not having been able to examine the Nevill types in the Calcutta Museum.

Fam. SOLARIIDÆ.

SOLARIUM (Lam.).

S. lævigatum (Lam.).

Worn specimens only.

TORINIA (Gray).

S. (*Torinia*) *delectabile* (Melvill), *n. sp.*

S. („) *homalaxis* (Melvill MSS.).

Both very rare. The latter not described at present, owing to its mamillate apex, and consequently young state. Allied to *S. virgatum* (Hinds). Some remarks will follow later on in this paper, upon this form, after the description of *S. delectabile.*

Fam. LITIOPIDÆ.

DIALA (H. and A. Adams).

D. Leithii (Smith).

ALABA (H. and A. Adams).

A rectangulata (Craven).

The former is a rare shell, apparently peculiar to Bombay. The latter an elegant little species with brown transverse lines and swollen white varices, not uncommon in shell sand.

Fam. RISSOIDÆ.

RISSOINA. (Orbigny).

R. Seguenziana (Issel) allied to *pulchra* (Adams).

R. (*Zebina*, H. & A. Ad.) *applanata* (Melvill) *sp. n.*

R. „ *canaliculata* (Schwartz).

R. (*Pyramidelloides*) *insolita* (Desh.).

R. sp.

RISSOA (Fremv.).

R. Versoverana (Melvill) *sp. n.*

ONOBA (H. and A. Ad.).

O. sp.

ALVANIA (Risso).

A. Mahimensis (Melvill) *sp. n.*

IRAVADIA (W. T. Blanford).

I. trochlearis (Gould).

FENELLA (H. and A. Ad.).

F. cerithina (Phil.).

FAIRBANKIA (W. T. Blanford).

F. Bombayana (Blanford).

We have named *Rissoina canaliculata* (Sch.) from specimens so labelled in the National Collection, S. Kensington, but we are doubtful whether the *R. ambigua* and *plicatula*, of Nevill's Catalogue, could we but examine the types now in the Calcutta Museum, would not clear up some difficulties with regard to them. *I. trochlearis* (Gould) is a beautiful white tranversely sulcated little species, not uncommon in shell sand; the sculpture of *R. insolita* (Desh.), is very curious. Other specimens of this genus we have at present unnamed, owing to the difficulty attending the synonyms throughout, and the want of a good monograph of the whole order.

Fam. HYDROBIIDÆ.

STENOTHYRA (Bern.).

S. Woodmasoniana (Nevill).

S. sp.

We have two, if not three, species of this closely-allied genus.

Fam. ASSIMINEIDÆ.

ASSIMINEA (Leach).

A. cornea (Leith).

Very small and obscure brackish water species; we have about three or four species altogether, but have not been able to differentiate them with absolute certainty, not having seen the named types. They will probably fall under the following names:—

A. Bombayana (Grateloup).

A. marginata (Leith).

A. subconica (Leith).

A. rotunda (Blanford).

Fam. CAPULIDÆ.

CRUCIBULUM (Schum.).

C. violaceum (Carp.).

Only worn specimens.

CALYPTRÆA (Lam.).

C. pellucida (Reeve), probably a variety of *C. sinensis* (L.).

ERGÆA (H. and A. Ad.).

E. Walshi (Hermannsen).

This last is common: *C. pellucida* (Reeve) does not appear to differ materially from the *C. sinensis* (L.) found on British shores, as well as many other parts of the world.

Fam. NATICIDÆ.

NATICA (Adanson).

N. lineata (Lam.).
N. maculosa (Lam.).
N. rufa (Bern.).
N. ala papilionis (Chem.), rare.
N. pulicaria (Phil.).
N. (*Neverita*, Risso) *didyma* (Bolten).
N. (*Mammilla*, Schum) *Zanzibarica* (Recluz).
N. (*Naticina*, Guild.) *fibula* (Reeve), rare.
papilla Gmelin), rare.
pomatiella (Melvill) sp. nov., rare.

SIGARETUS (Lam.).

S. Cuvierianus (Recluz), rare.
planulatus „ rare.

N. *lineata*, *didyma*, and *maculosa* are all common, and may be found alive in sandy places at low tides—*rufa* and *Zanzibarica* rarely found except during rough weather, when dead specimens get washed up. Among our specimens of *lineata* is one bearing five to six transverse canaliculations at somewhat irregular distances from each other, and giving a slightly angled appearance to the last whorl.

Fam. IANTHINIDÆ.

IANTHINA (Lam.).

I. communis (Lam.).

And another species.

RECLUZIA (Petit).

R. Rollandiana (Petit).

The former washed up in some quantity during rough weather, the latter rare.

Fam. SCALARIIDÆ.

SCALARIA (Lam.).

S. pretiosa (Lam.).

S. consors (C. and F.).

Surely this species is the same as *perplexa* (Pease).

S. aculeata (Sowb.).

(*Acrilla*, H. Ad.), *acuminata* (Sowb.)

minor (Sowb.)=*gracilis* (H. Adams).

A worn specimen of ours resembles *S. ovalis* (Sowb.), the locality of which does not seem to be known.

Species of this family are uncommon at Bombay. Only one specimen of *S. pretiosa* occurred.

Fam. EULIMIDÆ.

EULIMA (Risso).

Two species, undetermined at present. One of these is probably a novelty, with broad oblique mouth, ten whorled, whorls incurved, and a little distorted.

Fam. PYRAMIDELLIDÆ.

PYRAMIDELLA (Lam.).

P. pulchella (A. Ad.).

AMATHIS (H. and A. Ad.).

A. filia (Melvill), *sp. nov.*

OSCILLA (A. Ad.).

O. tornata (A. Ad. MSS. inedit.) *sp. nov.*

MONOPTYGMA (Gray).

M. fulva (Gray).

ODOSTOMIA (Fleming).

O. sp. Not yet worked out.

TURBONILLA (Leach).

T. sp. Four species.

PYRGULINA (A. Ad.).

P. casta (A. Ad.).
P. callista (Melvill), *sp. nov.*
P. Three other species, undetermined.

Fam. NERITIDÆ.

NERITA (Adanson).

N. oryzarum (Récluz).
albicilla (Linn.).
polita (Linn.).

NERITINA (Lam.).

N. crepidularia (Lam.).
pulchella (Reeve).

N. oryzarum is extremely common under stones at half-tide, and is variable both in shape and colouring. *Nerita Longii* (Récluz), *Dombeyi* (Récluz) and *quadricolor* (Gmelin) have all been mentioned as found in Bombay, but out of a large number of specimens we have not been able to set apart any as truly distinct from the *oryzarum* type.

Fam. TURBINIDÆ.

TURBO (Linn).

T. elegans (Phil.)=*intercostalis* (Phil.).

ASTRALIUM (Link.).

A. stellatum (Gmelin).
Both common.

Fam. TROCHIDÆ.

TROCHUS (Linn).

T. (*Polydonta*, Schum.) *radiatus* (Gmelin).

CLANCULUS (Mont.).

C. depictus (A. Ad.) = *Trochus scabrosus* (Phil.)?

We think these two must be forms of one species. White specimens of *C. depictus* are also not unfrequent, and may be designated as var. *albidus.*

C. ceylanicus (Nevill).

ISANDA (H. and A. Ad.).

I. crenulifera (A. Ad.).

ROTELLA (Lam.), = UMBONIUM (Link.).

R. vestiaria (Lam.) and var. *elegans* (Beck).

GIBBULA (Risso).

G. Swainsonii (A. Ad.).

ZIZYPHINUS (Gray).

Z. scobinatus (Adams). Not common. Peculiar to Bombay shores.

EUCHELUS (Phil.).

E. tricarinatus (Lam.).

var. *horrida* (Phil.).

Indicus (A. Ad.).

T. radiatus is extremely common, and some specimens appear to agree very closely with *incrassata* (Lam.). *C. depictus* and *E. Indicus* also abound, and the little bright coloured *R. vestiaria* is present in countless millions, in many beautifully coloured varieties.

Fam. DELPHINULIDÆ.

LIOTIA (Gray).

L. pulchella (Dunker). Our specimens of this little shell agree very closely with *Cyclostrema eburneum* (Nevill), so far as we can judge from the figure.

CYCLOSTREMA (Marryat).

C. solariellum (Melvill), *sp. nov.*

C. cingulatum (Dunker).

Fam. HALIOTIDÆ.

HALIOTIS (Linn).

H. rufescens (Sowb.).

A large species, of which we have only one somewhat imperfect specimen, from Bombay. It occurs also at Ceylon.

Fam. FISSURELLIDÆ.

FISSURELLA (Brug.).

F. Bombayana (Sowb.) = *lima* (Sowb.).

This shell is very variable, being sometimes oval, and at other times a good deal elongated. In colour it is white to blackish brown, and sometimes rayed with brown.

EMARGINULA (Lam.)

E. elongata (Phil.).

E. radiata (Gould).

SCUTUM (Montfort).

S. unguis (Linn.).

This shell is pretty common on muddy rocks and under stones. The animal envelopes the whole shell, excepting the very apex.

Fam. PATELLIDÆ.

PATELLA (Linn).

P. aster (Reeve).

This shell is very common, and perhaps another species also occurs.

CLYPIDINA (Gray).

C. notata (Linn.).

Fam. SCAPHOPODA.

DENTALIUM (Linn.).

D. longitrorsum (Reeve).

And another species of which our specimens are in too young a condition to name.

CADULUS (Phil.).

C. gadus (Sowb.).

Most abundant in shell-sand.

PELECYPODA.

Fam. OSTREIDÆ.

OSTREA (Linn.).

O. crenulifera (Sowb.) = *plicata* (Chem.).

O. bicolor (Hanley).

We give these names as most closely corresponding to the Bombay specimens that have come under our notice, but this family is so widely distributed in all seas, and the similarity of shell sculpture is so close, whilst the shape is so varied, and also frequently encrusted with nullipores, that it is impossible to speak with absolute certainty.

O. lacerata (Hanley). Found on stones at low tide, densely clustered, and arranged vertically.

Fam. ANOMIIDÆ.

ANOMIA (Linn.).

A. Achaeus (Gray). Common.

A. (*Ænigma*) *aenigmatica* (Ant.).

PLACUNA (Brug).

P. placenta (Linn.)

Very common.

Fam. SPONDYLIDÆ.

SPONDYLUS (Linn.).

S. rubicundus (Reeve).

S. Nicobaricus (Chem.).

Both species uncommon, and only imperfect specimens obtained.

Fam. PECTINIDÆ.

PECTEN (P. Belot).

P. senatorius (Gmel.).

P. Singaporinus (Sowb.).

This family is very poorly represented, and only worn and small specimens of the above were collected.

Fam. AVICULIDÆ.

PINNA (Linn.).

P. nigra (Chem).

A single specimen found attached by its byssus to a clump of stones.

Fam. MYTILIDÆ.

MYTILUS (Linn.).

M. smaragdinus (Chem.).

MODIOLA (Lam.).

M. (*Brachydontes*) *emarginata* (Benson).

Shells belonging to this family rare in Bombay, but commoner to the south.

Fam. ARCIDÆ.

ARCA (Linn.).

A. bistrigata (Dunker).

A. (*Scapharca*, Gray) *inaequivalvis* (Brug).

A. „ *Japonica* (Reeve).

A. „ *rhombea* (Bern.).

A. (*Anadara*, Gray) *granosa* (Lam.).

A. (*Barbatia*, Gray) *obliquata* (Wood).

A. „ *lactea* (Linn.).

A. (*Acar*, Gray) *tenebrica* (Reeve).

Fairly largely represented in Bombay, and *inaequivalvis*, *granosa*, and *bistrigata* all common, the last-named attached to rocks and stones by a strong byssus. *Obliquata* occurs commonly at Aden, but is rare at Bombay, while *rhombea* is likewise found at Ratnagiri. *Lactea* very common, and also reported from Japan, Aden, Coast of Africa, Mediterranean, and British waters; this includes *A. Zebuensis* (Reeve).

Fam. NUCULIDÆ.

NUCULA (Lam.).

N. Layardi (Adams).

LEDA (Schum.)

L. (*Nuculana*, Link.) *Mauritiana* (Sowb.).

YOLDIA (Möller).

Y. Nicobarica (Brug).

Specimens of this family are uncommon.

Fam. CARDITIDÆ.

CARDITA (Brug.).

C. antiquata (Lam.).

C. calyculata (Lam.).

The former is very common at Bombay, while the latter occurs at Ratnagiri.

Fam. CARDIIDÆ.

CARDIUM (Linn.).

C. coronatum (Speng.) = *Asiaticum* (Brug.).

C. latum (Bern.).

Coronatum is extremely common, and from an examination of a vast quantity of specimens, we conclude that *Asiaticum* is merely a larger form of the same shell.

Latum is uncommon, some specimens covered with a bristly epidermis, others nearly smooth.

Fam. CHAMIDÆ.

CHAMA (Linn.).

C. macrophylla (Chem.).

A single specimen from Bombay is, without much doubt, this species, which is of unusually wide distribution, having its centre of distribution in the West Indies.

Fam. CYPRINIDÆ.

LIBITINA. (Schum.) = CYPRICARDIA (Lam.).

L. vellicata (Reeve). Common.

Fam. VENERIDÆ.

MERETRIX (Lam).

M. morphina (Lam.)

b. Var. *castanea* (Lam.).

c. Var. *petechialis* (Lam.).

d. Var. *impudica* (Lam.).

Very common, and our range of specimens show these forms merging into each other, though usually considered distinct species.

CIRCE (Schum.).

C. divaricata (Chem.).

Very common amongst muddy stones.

MEROE (Schum.).

M. effossa (Hanley).

M. Solandri (Gray).

M. hians (Wood) = *Solandri.*

M. contempta (Smith) = *Solandri.*

M. effossa is very common in sand. *Solandri* also very common, and it is a question whether there are more than these two species at Bombay. From an examination of a large quantity of perfect specimens, we come to the conclusion that *hians* and *contempta* are only *Solandri* in various younger stages of growth.

DOSINIA (Scopoli).

D. pubescens (Phil.).

D. gibba (Adams).

D. rustica (Romer).

D. prostrata (Linn.).

D. pubescens is fairly common in all stages of growth. Young specimens are nearly circular, silky in appearance, and often tinged with pink; in the older forms the beak becomes more prominent, and shell somewhat elongated. *Rustica* is somewhat closely allied in form, but is rougher and more chalky in texture. *D. prostrata* is easily known by its light brown and slate-coloured tinge, and is only found during seasons of rough weather.

VENUS (Linn.).

V. imbricata (Sowb.)

This little shell abounds in the sandy shingle of the shore.

V. (*Chione*, Megerle) *cor.* (Wood), also found at Karachi.

V. „ *pinguis* (Hinds.).

V. „ *Layardi* (Reeve) = Ratnagiri.

V. „ *radiata* (Chem.) = *Tapes marmorata* (Lam.)

„ *orientalis* (Reeve).

C pinguis and *radiata* are extremely common, and the latter is very variable in shape, young specimens being of the typical *Tapes* form, whilst the old ones become much more gibbous. Both are much sought for edible purposes, and perfect specimens of all growths can easily be obtained.

V. (*Anaitis*, Römer) *isabellina* (Phil.), Rare.

CLEMENTIA (Gray).

C. papyracea (Gray).

A single valve, which we cannot think can be other than this species, though it is smaller than the typical specimen.

TAPES (Megerle).

T. (*Pullastra*, Sowb.) *Malabarica* (Chem.).

T. „ *textrix* (Chem.).

T. „ *Indica* (Sowb.)

These are all beautiful shells when perfect, and *T. Malabarica* and *T. textrix*, the latter especially, are common. With *textrix* the general form is very smooth and shiny, but old specimens are often irregularly concentrically striated and lose the characteristic web markings.

VENERUPIS (Lam.).

V. macrophylla (Desh.

N.B.—*Petricola bipartita* (Desh.) There are specimens in the British Museum of this shell from Bombay, but we have not been fortunate enough to find it ourselves.

Fam. GLAUCOMYIDÆ.

GLAUCOMYA (Woodward) = GLAUCONOME (Gray).

G. cerea (Reeve).

A fairly common little shell, living in brackish waters.

Fam. UNGULINIDÆ.

DIPLODONTA (Brown) = MYSIA (Leach).

D. Indica (Desh).

D. rotundata (Turton).

D. Indica is frequently met with as a little delicate globular shell, the full grown specimens being only found at times of rough seas. *D. rotundata*—This British shell occurs at Aden, and a valve or two of what appears to be the same is in our collection.

Fam. DONACIDÆ.

DONAX (Linn.).

D. scortum (Linn.).

D. incarnatus (Chem.) = *Dysoni* (Desh.).

D. abbreviatus (Lam.).

All are pretty common.

D. Dysoni appears to be *incarnatus* in a young form, and is frequently prettily coloured with pink and purple.

D. abbreviatus is sometimes pure white inside and out, and sometimes deep purple inside and brown outside, with all intermediary variations.

Fam. PSAMMOBIIDÆ.

PSAMMOBIA (Lam.).

P. Malaccana (Reeve) = *pallida* (Desh.). Rare.

SOLENOTELLINA (Blainv.).

S. (*Psammotæa*, Lam.) *atrata* (Desh.).

ASAPHIS (Modeer) = CAPSA (Brug.).

A. deflorata (Linn.) = *Sanguinolaria* vel *Capsa rugosa* (Lam.)

P. atrata is the only purple bivalve in Bombay, and is fairly common.

A. deflorata. Dead specimens only found of this large and handsome shell.

Fam. SOLENIDÆ.

SOLENOCURTUS (Blainv.).

S. exaratus (Phil.). Rare.

SILIQUA (Megerle).

S. albida (Dunker).

SOLEN (Linn.).

S. truncatus (Sowb.).

S. brevis (Hanley).

The *Siliqua* is not common, but both forms of *Solen* are, and when young the shells are so closely allied that it is difficult to differentiate them.

Fam. MACTRIDÆ.

MACTRA (Linn.).

M. plicataria (Linn.). Rare.

M. cornea (Desh.) Rare.

M. Luzonica (Desh.).

Luzonica is not uncommon, and it seems generally distributed over the whole Indian peninsula, as we have seen specimens from Madras and Calcutta.

RAETA (Gray).

R. Abercrombiei (Melvill) *sp. nov.* Only found after rough weather.

HARVELLA (Gray).

H. (*Standella*, Gray) *capillacea* (Desh.).

H. (*Standella*) *pellucida* (Chem.).

Both these shells are common, and attain a large size, say 4″ × 2½/3″. Only dead specimens procured.

LUTRARIA (Lam.).

L. planata (Chem.). Rather rare.

L. (*Caecella*, Gray) *transversalis* (Desh.). Fairly common.

Fam. MYIDÆ.

CORBULA (Brug).

C. modesta (Hinds).

Rare at Bombay, but occurring to the South in some quantity.

CRYPTOMYA (Conrad).

C. Philippinarum (A. Ad.).

One specimen collected by Mr. Herford, besides two of our own. Although all are dead specimens, and not in good condition, we identify them with this Philippine species with considerable certainty.

Fam. PHOLADIDÆ.

PHOLAS (Linn.).

P. (*Barnea*, Leach) *Bakeri* (Desh.).

P. (*Martesia*, Leach) *striata* (Lam.).

Single valves of *P. Bakeri* are common, but the live shell we have not met with.

Fam. LUCINIDÆ.

LUCINA (Lam.).

L. fibula (Reeve). From Ratnagiri. A species of very wide distribution, occurring in the Tropics of both hemispheres.

Fam TELLINIDÆ.

TELLINA (Linn.)

T. capsoides (Lam.).

T. emarginata (Sowb.).

T. Kolabana (Melvill), *sp. nov.*

T. (*Homala*, Schum.) *ala* (Hanley).
T. „ *sinuata* (Spengler).
T. (*Angulus*, Megerle) *rubra* (Desh.) = *culta* (Hanley).
T. „ *rubella* (Desh.).
T. (*Mocra*, H. and A. Adams) *lechriogramma* (Melvill) *sp. nov.*

GASTRANA (Schum.)

G. Brugieri (Hanl.)
G. (*Metis*, H. and A. Adams) *edentula* (Spen.). = *angulata* (Chem.).
G. „ *polygona* (Chem.).
G. (*Macoma*, Leach) *truncata* (Jonas).

Specimens of this large family abound in Bombay waters, and the first four are very common. *G. edentula* and *M. truncata* are equally plentiful. *T. rubra* and *rubella* seem more plentiful to the south, as we obtained many specimens from Ratnagiri. Of *G. polygona* only a few valves were found after rough weather. We have another small orange pink shell belonging to this family, but as it appears to be young, we await further specimens before attempting to differentiate it.

Fam. SCROBICULARIIDÆ.

ABRA (Leach) = SYNDOSMYA (Récluz).

A. opalina (Hinds). Rare.

SEMELE (Schum.) = AMPHIDESMA (Lam.).

S. cordiformis (Sowb.).
S. regularis. (Sm.).

S. cordiformis is common in muddy places, though described by Reeve as a shell of extreme rarity. Of *regularis* we have only one valve, which appears to agree with specimens of this name in the British Museum, though it is also allied to *scabra* (Hanley).

Fam. PANDORIDÆ.

PANDORA (Brug.).

P. flexuosa (Sowb.).

Common in shingle.

Fam. ANATINIDÆ.

ANATINA (Lam.).

A. labiata (Reeve).

Found in some quantity amongst seaweed cast up by a storm, otherwise rarely met with, perhaps because of its extreme fragility.

THRACIA (Blaine.).

T. Salsettensis (Melvill), *sp. nov.*

Like the last, extremely fragile, which may account for so large and fine a shell having hitherto escaped description. Have only met with single valves.

Fam. LINGULIDÆ.

LINGULA (Brug.).

L. hians (Swainson).

Dug up in quantity at low tides out of black mud.

N.B.—The arrangement followed is that adopted by M. Paul Fischer in the *Manuel de Conchyliologie*, 1887.

* * * *

Whilst these sheets have been passing through the press, we have had the opportunity of perusing a very interesting article by a writer signing himself 'Keswal,' in the *Journal of the Bombay Natural History Society*, in which much pleasant, if discursive, information is given about the productions of the waters of Western India, especially those of the Konkan region. He does not name, however, any specimens of *Mollusca* (excepting one or two *Cephalopoda*), to which we have not already made reference.

Descriptions of Twenty-five New Species of Marine Shells from Bombay. Collected by Alexander Abercrombie, Esq. By James Cosmo Melvill, M.A., F.L.S.

(Received November 15th, 1892.)

MUREX (OCINEBRA) BOMBAYANUS *sp. nov.* (Pl. 1, f. 1).

M. testâ fusiformi, ochraceo-cinereâ, squamatâ, apice acuto, anfractibus septem vel octo, angulato-costatis, ultimo anfractu varicibus octo, in medio trinis angulorum ordinibus transversim succincto, aperturâ ovato-oblongâ, pallescente, labro intus denticulato, canali brevi.

Long. spec. typ. 31 mill.

Lat. 16 mill.

Hab. Bombay, common along the coast (*A. Abercrombie, Herford, W. T. Blanford* (in Mus. Brit.). Ratnagiri (*A. Abercrombie*).

Evidently a very abundant species, and in all probability extending some way both North and South of Bombay. The largest of the many specimens I have seen measures 35 millimetres longitudinally. It is a very uniform species in all stages of its growth, and would appear to have been confounded with *M. luculentus* (Reeve). Its nearest ally, however, would seem to be *M. cristatus* (Brocchi) from the Mediterranean, from which, however, it is quite distinct. Some specimens are pale yellow, with faint brown transverse fasciæ.

PLEUROTOMA (CLAVUS) PRÆCLARA, *sp. nov.* (Pl. 1, f. 2).

P. testâ pyramidato-fusiformi, percrassâ, pallidé ochraceâ, anfractibus septem vel octo, ad suturas valide impressis, longi-

tudinaliter obliqué pluricostatis, transversim regulariter liratis, aperturâ oblongâ simplice, labro exteriore in medio crassiusculo, canali brevissimâ, margine columellari obliquiplanato.

Long. 44 mill.

Lat. 16 „

Hab. Bombay, up the coast (*Abercrombie*).

A large, conspicuous species, of which all the specimens before us are somewhat worn : not sufficiently so, however, as to efface the sculpture.

From *P. Atkinsoni* (Smith), *crenularis* (Lam.), *flavidula* (Lam.) it is quite distinct, being more allied to the smaller *sacra* (Reeve), in my opinion ; and a member of the subgenus *Clavus*, rather than *Drillia*. As Tryon, however, rightly observes, the subgenera allotted to the larger *Pleurotomæ* are not always very well defined.

PURPURA (STRAMONITA) BLANFORDI, *sp. nov.*
(Pl. 1, f. 3).

P. testâ ovato-fusiformi, crassâ, cinereo-carneâ, anfractibus quinque, longitudinaliter tuberculato-costatis, undique transversim regulariter et arcté liratosulcatis, costis in medio conspicué unangulatis, ultimo anfractu binâ serie tuberculato, aperturâ ovatâ, carneâ, labro extus biangulato, intus denticulato, margine columellari recto, simplice.

Long. 27 mill.

Lat. 18 „

Hab. Bombay and Ratnagiri (*A. Abercrombie, Herford*, and also *W. T. Blanford* in Brit. Mus.), Kurrachee (Brit. Mus.). (*Blanford*).

This species would appear common upon the rocks of the West Coast of India. We have seen specimens from Kurrachee, and believe the same shell occurs in Ceylon.

The two specimens collected by Mr. Abercrombie, one of which is figured, are the only ones I have seen quite perfect as regards completion of growth. In size it assimilates *P. Tissoti* (Pet.), with which, also abundant on these shores, it has been confounded. It is easily to be differentiated, since it does not possess the deep bisulcate transverse grooving of *P. Tissoti*, nor the revolving raised ridges with small nodules equi-distant thereupon.

RICINULA (SISTRUM) SUBNODULOSA, *sp. nov.* (Pl. 1, f. 6).

R. testâ turritâ, fusiformi, solidâ, apice acuto, anfractibus octo vel novem, in medio angulatis, tranversim squamato-corrugatis, ultimo anfractu bino ordine noduloso, et infra, duobus minoribus ordinibus nodulorum succincto, aperturâ oblongâ lividâ, labro extus angulato, intus livido, denticulato, margine columellari recto.

Hab. Bombay. (*Abercrombie, Herford.*)

Long. spec. typ. 20 mill.

Lat. 9·20 „

Bearing a little resemblance to the West Indian *R. nodulosa* (C. B. Adams), but the black rows of nodules stand out more prominently upon a lighter ground, the interstices between which on the last whorl give a semblance of a *fascia*. The shell is also more elongate than *R. nodulosa*. One of Mr. Herford's specimens is larger than usual (23 mill.), the smallest with lip perfect, only 11 mill., but the essential characters are preserved in each.

RICINULA (SISTRUM) KONKANENSIS, *sp. nov.* (Pl. 1, f. 5).

R. testâ pyramidato-fusiformi, solidâ, livido cinereâ, apice attenuato, acuto, anfractibus quinque-sex, longitudinaliter plicato-costatis, transversim nigro-nodulosis, interstitiis transversim squamulosis, aperturâ ovatâ cinereâ, labro extus muriculato, intus denticulato, margine columellari recto.

Long. 29 mill.

Lat. 15 „

Hab. Bombay (*Blanford, Abercrombie, &c.*).

Not unfrequent. Has been hitherto confounded, judging from the specimens in the National collection, with *R. affinis* and *R.* (*Sistrum*) *concatenata* (Reeve).

RICINULA (SISTRUM) XUTHEDRA, *sp. nov.* (Pl. 1, f. 4).

R. testâ fusiformi, solidâ, læté flavidâ, anfractibus sex, longitudinaliter costatis, costis albonodulosis, transversim inter costas tenuiliratis, aperturâ albâ, ovatâ, labro intus denticulato, apud marginem columellarem trinoduloso.

Long. 15 mill.
Lat. 8 „
Hab. Ratnagiri (*A. Abercrombie*).

A beautiful yellow-ochraceous species, with longitudinal white noduled ribs, mouth ovate, white, outer lip denticulated within, and two or three nodules on the columellar margin. A form on the border-land between *Sistrum* and *Engina*. Four specimens.

ENGINA ZEA, *sp. nov.* (Pl. 1, f. 7).

E. testâ conico-pyramidali, solidiusculâ, apice acuto, anfractibus octo, transversim nodulis nitidis variegatis arcte accinctis, interstitiis duplici, vel-triplici striatosulcatis, ultimo anfractu longitudinaliter costiplicato, in medio transversim albizonato, aperturâ ovato-trigonali, ad basin angustâ, labro externo incrassato, variegato, intus lirato, et apud marginem columellarem crassi-striato.

Long. 18 mill.
Lat. 9·50 „
Hab. Bombay (*A. Abercrombie*). There are also specimens in Mus. Brit., collected by Mr. W. T. Blanford, F.R.S., from the same locality.

This species has apparently been confounded with *E. armillata* (Reeve), from which it differs both in form and marking. I have had specimens for more than twenty years lying unnamed in my collection, and there are others, likewise unnamed, in the British Museum.

It is a conical, sharp-pointed little shell, acutely broad in the middle, giving a quadrate appearance to its contour, becoming rapidly attenuate at both ends. Round the centre of the last whorl runs a conspicuous white median band, formed of white transverse nodules, the rest of the surface of the shell being nodulous, and variegated brown and white.

The mouth is triangular-ovate, outer lip exteriorly variegated, inner with small white ridges, and on the columellar margin are several raised short white ridges.

The similarity to grains of maize (ζέα) suggested the trivial name.

COLUMBELLA (MITRELLA) FLAVILINEA, *sp, nov.*
(Pl. 1, f. 8).

C. testâ tenui, lævi, anfractibus sex vel septem, ad suturas subcompressis, tranversim lineis angustis flavidis, hic illic speciminibus quibusdam interruptis, in aliis continuis, conspicué decoratis; aperturâ oblongâ, labro exteriore paullum angulato, intus simplice, lævi.

Long. 5 mill.

Lat. 2·50 „

Hab. Bombay (*Abercrombie*).

Not uncommon; allied to *C. Marquesa* (Gaskoin), of which one good specimen was also found in shell sand from the same locality. The shell is small, smooth, ornamented with painting of narrow, usually continuous, but in some specimens interrupted, yellow lines. Several examples.

COLUMBELLA (MITRELLA) EUTERPE, *sp. nov.* (Pl. 2, f. 9).

C. testâ attenuatâ, fusiformi, tenui, subpellucidâ, lævi, anfractibus septem, infrá suturas ochraceo-flammulatis et *albomaculatis, ultimo anfractu in medio anguste albo-lineato infrá arcté brevibus flammis ochraceis decorato, aperturâ angusté oblongâ, labro simplice.*

Long. 6 mill.

Lat. 2·50 „

Hab. Bombay (*Abercrombie*).

A very few specimens, and those mostly imperfect, have occurred of this little *Mitrella.* Its whorls, seven in number, and quite smooth, are ornamented with flame-like zigzag markings at the sutures, and extending over the whorls, also ornamented with opaque white marks and blotches. In the last whorl there is a pale median transverse line caused by the cessation of the above-mentioned flammulate markings, which recommence, however, below, towards the base, in many thin, almost straight, yellow lines. Mouth simple, narrowly oblong.

MARGINELLA (GIBBERULA) MAZAGONICA, *sp. nov.* (Pl. 1, f. 10)

M. testâ ovato-conicâ, parvâ, subpellucidâ, lævi, anfractibus quatuor, apice obtuso, ultimo anfractu rapidé accrescente, aperturâ angustâ, oblongâ, labro exteriore intus denticulato, columellâ quadriplicatâ.

Long. 3 mill.

Lat. 2 „

Hab. Bombay. (*A. Abercrombie*). Very abundant.

A short stout conical little species, of ivory whiteness, and quite smooth, lip denticulate within, and columellar four-plaited. Allied to *M. minuta*, (Pfr.) and *M. Lavalleana* (D'Orb.), with neither of which it seems exactly to correspond.

SOLARIUM (TORINIA) DELECTABILE, *sp. nov.* (Pl. 1, f. 11).

S. testâ parvâ, profundé umbilicatâ, depresso conicâ albescente, delicatulâ, subpellucidâ, anfractibus quatuor, gradatulis, *ultimo rapidé accrescente, undique transversim arcté albo-gemmulatis, interstitiis sub lente obliquostriatis, circà umbilicum bino gemmularum ordine majorum, nitentium, diposito apertura tenui, labro simplice, fimbriato, subrotundo, apud marginem columellarem reflexo.*

Long. 2·50 mill.

Lat. 3 „

Hab. Bombay (*Abercrombie*).

Two or three specimens of an unusually lovely little semi-transparent white species, occurring in shingle and shell sand from Bombay. The form is depresso-conical, white beaded, wonderfully closely obliquely striated at the interstices between the beading; this is not distinguishable without a lens. The umbilicus has two rows of beads around it, one large with coarser gemmulæ, very shining; the other with smaller and more delicate granulation. Mouth thin, round, fimbriate, reflexed at the columellar margin.

[N.B.—Another species of *Solarium* § *Torinia*, probably new, occurred with the above, allied to *S. virgatum* (Hinds). This species is white, very depressed, quadrate, with similar transverse raised beading; at the periphery the gemmulæ are larger and coarser, as also in the last row nearest the umbilicus at the base. Mouth simple, quadrate. Apparently quite a young shell. I have provisionally named it *S. homalaxis*, but await further specimens before attempting a full description.

Long. 1 mill.

Lat. 2·50 „

Hab. Bombay.]

AMATHIS FILIA, *sp. nov.* (Pl. 1, f. 14).

A. testâ aciculato-fusiformi, albidâ, turritâ, semipellucente, nucleo apicis vitreo, anfractibus septem, lævibus, ad suturas gradatulis, impressis, infrá suturas internâ lineâ plicariâ *circumambiente, aperturâ oblongâ, labro simplice, columellâ spiraliter uniplicatâ.*

Long. 4 mill.

Lat. 1·20 „

Hab. Bombay (*Abercrombie*).

An attenuate shining white fusiform little species, allied to *A. virgo* (Adams), from Japan; the mouth is oblong, columella strong, spirally plaited. The whorls are turreted, smooth, semi-pellucid, with the internal plica showing through as a transverse clouded line just below the sutures. Two or three specimens only.

OSCILLA TORNATA, *sp. nov.* (Pl. 1, f. 12.)

[*Oscilla tornata*, Arthur Adams MSS. inedit.]

O. testâ fusiformi, albidâ, anfractibus septem, apud suturas profundè canaliculatis, transversim tricostatis, costis binis infrâ suturas, parvo sulculo intercepto, tertiâ costâ ab his à canali profundâ divisâ, sicut apud suturas, aperturâ ovatâ, albidâ, subpellucente, labro externo sulculoso, extus et intus, columellari conspicuè et rectè uniplicato.

Long. 3·10 mill. (*sp. majoris*).

Lat. 1·50 „

Hab. Bombay (*Abercrombie*).

This wonderful little transversely sulcate and grooved species has some external resemblance to *Irawadia trochlearis* (W. T. Blanford), but can be at once distinguished by the plicate columella. There are four or five described species of this genus, mostly of Mr. Arthur Adams' naming, from Japan. In the British Museum is a specimen, also from Japanese seas, with the name as above, entirely comparable with our shell. He does not seem to have ever described it, as was, unfortunately, often his practice in his later years, especially amongst these smaller and critical genera. The consequence has been to still further render unsolved and difficult the nomenclature of these extremely beautiful but very microscopic genera and species.

In *O. tornata* the transverse ribs are three in number, two below the deeply-channelled sutures, followed by a similar deep groove, and then a third transverse costa, just above the suture of the next whorl.

Three specimens obtained in shell sand. Very rare.

PYRGULINA CALLISTA, *sp. nov.* (Pl. 1, f. 13).

P. testâ delicatulâ, subpellucidâ, attenuato-fusiformi, anfractibus septem, ad suturas profundè angulato-canaliculatis, longitudinaliter-costis regularibus subobliqué decoratis, interstitiis lævibus, ultimo anfractu infrá suturas transversim fortiter unilirato, ad dorsum bino lirarum ordine, aperturâ ovato-oblongâ, labro quadratulo, ad marginem columellarem uniplicato.

Long. 4 mill.

Lat. 1·10 „

Hab. Bombay (*Abercrombie*).

One of the most exquisite little shells, so far as sculpture is concerned, that it is possible to imagine. The shell is seven-whorled, deeply angularly channelled at the sutures, with raised transverse border at either end of the whorl, the borders joined by slightly oblique liræ, smooth at the interstices, the last whorl having a conspicuous angular transverse border line, and at the back of the shell another parallel to this, the lip is subquadrate, and the columellar margin with a very conspicuous plait.

Two or three specimens in shell sand. Very rare.

RISSOINA (ZEBINA) APPLANATA, *sp, nov.* (Pl. 1, f. 16).

R. testâ albâ, nitidâ, sublævi, fusiformi, apice obtuso, an-

fractibus sex, convexiusculis, longitudinaliter obscurissimé costulatis, aperturâ ovatâ, labro paullum incrassato, simplice.

Long. 5 mill.

Lat. 1·75 „

Hab. Bombay (*Abercrombie*).

A small smooth white species, allied no doubt to *R.* (*Zebina*) *sublævigata* of Nevill from the Andaman Islands, but apparently differing in being indistinctly longitudinally costulate, whilst the *R. sublævigata* is virtually smooth.

RISSOA VERSOVERANA, *sp. nov.* (Pl. 1, f. 15).

R. testâ parvâ, delicatulâ, ovato-oblongâ, semipellucente, anfractibus sex, ventricosis, ad suturas impressis, longitudinaliter subobliqué costatis, ad basem anfractûs ultimi feré obliteratis, tranversim tenuiliratis, aperturâ rotundâ, labro tenui, simplice.

Long. 2 mill.

Lat. 1·20 „

Hab. Bombay (*Abercrombie*).

A small, very abundant species in shell sand, that we cannot find has been characterized or described. The longitudinal costæ at the base of the last whorl are in most specimens only faint or entirely obliterated.

ALVANIA MAHIMENSIS. *sp. nov.* (Pl. 1, f. 17).

A. testâ oblongâ, solidâ, corrugatâ, apice obtuso, anfractibus quinque vel sex, longitudinaliter costulatis, costis transversim cancellatis, infrá suturas et ad basin ultimi anfractûs rubro-coloratis, aperturâ ovali, labro planulato, incrassato.

Long. 2·75 mill.

Lat. 1·50 „

Hab. Bombay (*Abercrombie*).

A pretty species of *Alvania*, being lightly longitudinally ribbed, with transverse cancellations. Below the sutures there is a red transverse band, which also shews near the base of the last whorl, the lip is roundish-oval, solid, somewhat incrassate and flattened. Several specimens.

NATICINA POMATIELLA, *sp. nov.* (Pl. 1, f. 18).

N. testâ angusté sed profundé umbilicatâ, elevato-conicâ, subpellucidâ, albidâ, feré lævi, anfractibus quinque, ad suturas canaliculatis, obscuré transversim liratulis, aperturâ ovatâ, labro simplice, apud umbilicum paullum reflexo.

Long. 17 mill.

Lat. 12 „

Hab. Bombay (*Abercrombie*).

A curious species, and with the form of *Amauropsis canaliculata* (Gould). It is narrowly but deeply umbilicated, and apparently smooth and white, but under a lens the surface is seen to be very delicately tranversely grooved. This may be more apparent in a fresh specimen, ours being rather worn shells. At the sutures there is a deep channel, the mouth is simple, white within.

One or two specimens; rare.

CERITHIOPSIS (SEILA) BANDORENSIS *sp. nov.* (Pl. 1, f. 19).

C. testâ attenuatâ, brunneâ, solidâ, anfractibus duodecim, ad apicem pallidis, transversim quadriliratis, liris rotundis paullum diversis, majoribus minoribus alternantibus, vel binis æqualibus, tertiâ minore, aperturâ rotundâ, labro simplice, margine columellari recto.

Long. 7 mill (*sp. maj*).

Lat. 2 „

Hab. Bombay (*Abercrombie*).

A plain brown transversely round-ribbed species, a little like *Telescopium fuscum* in miniature as regards sculpture, but not so broad proportionately as that species, being uniformly attenuate. The apex is whitish, whorls about 12, transverse ribs somewhat varying in size, about four in a whorl.

Rare. Two specimens only.

CYCLOSTREMA SOLARIELLUM, *sp. nov.* (Pl. 1, f. 20).

C. testâ minutâ, albescente, tenui, depressâ, profundè umbilicatâ, anfractibus quatuor, ultimo rapide accrescente, undique transversim tenui-liratis, infrá suturas binis gemmularum ordinibus decoratis, et ad basin circá umbilicum simili modo bigemmulatis, aperturâ rotundo-ovatâ, labro simplice.

Long. 0·50 mill.

Lat 1·50 „

Hab. Bombay (*Abercrombie*).

A very small shell, with some of the aspect of a small *Torinia*; it also to some extent resembles *C. Tatei* (Angas), from S. Australia, but the double row of gemmules on the liræ below the sutures, and at the base, around the umbilicus, distinguish it from that species.

Not uncommon in shell sand.

Surely *Cyclostrema* is neuter, being instituted by the late Captain Marryat, R.N., the famous novelist (who added the study of the Mollusca to his many other accomplishments), in 1817, as derived from κύκλος and τρῆμα. It has been considered feminine by most writers and authors, including Captain Marryat himself.

SIPHONARIA BASSEINENSIS, *sp. nov.*, (Pl. 1, f. 21)

S. testâ subconicâ, oblongâ, tenui, lævi, nigrobrunneâ, biradiatâ, intus brunneâ, ad marginem radiatâ.

Long. 9 mill. (*sp. majoris*)

Lat. 6 „

Hab. Bombay (*Abercrombie*).

A small subconical plain smoothish brown species, with biradiate flames round the margin. I had thought this, of which very numerous examples occur in Mr. Abercrombie's collections, must be a young form of some perhaps well-known species, but I am assured this is not the case, Mr. Abercrombie having had unusual facilities for studying the growth of the species, so very abundant all round the Bassein and Mahim coasts. Mr. Edgar Smith also concurs in this view, that it is a mature species, and different from the many already described, though it presents no very important salient features.

Raeta Abercrombiei, *sp. nov.* (Pl. 1, f. 25).

R. testâ pertenui, hyalinâ, lacteâ, oblongo-ovatâ, posticé rostratâ, anticé ovatâ, gibbosulâ, concentricé confertim undato-plicatâ, tumescente, cordatâ, umbonibus parvis.

Long. 23 mill.

Lat. 30 „

Hab. Bombay (*Abercrombie*).

A most beautiful, delicate, white papyraceous shell, concentrically closely wave-ribbed, belonging to a small genus which I do not find has hitherto been recorded from the shores of Hindostan, though a nearly allied species *R. Grayi* (A. Adams) is reported from Borneo. From this shell *R. Abercrombiei* differs in its more close and regular transverse plications, and the greater delicacy of the shell. It would be interesting if, in years to come, an intermediate form between the two were discovered on either the Eastern coast of India, or in the Malay Peninsula; it is more than likely other species of this genus, hitherto so restricted, will reward the collector. The type *R. canaliculata* (Gray) is extremely common on the sandy sea coasts of South Carolina, and another larger and coarser species *R. Californica* (Sowb.) is an inhabitant of the Western coasts of the United States. *R. pulchella* (Ad. and Reeve) a very small and delicate form, occurs in the Eastern Islands, and a few other species have been described, but are hardly known.

Tellina Kolabana, *sp. nov.* (Pl. 1, f. 23).

T. testâ ovatâ, albescente, solidiusculâ, convexâ, latere postico valdé bicarinato, antico oblongo, transversim concentricé liratâ, *apud umbones feré lævi, flavo tinctâ, posticé asperâ, usque ad marginem ventralem.*

Lat. 27 mill.

Long. 17 „

Hab. Bombay (*Abercrombie*).

A somewhat thickened shell, as *T. Balthica* (L.) ; white, yellow or orange-tinted at the umboes, convex, distinctly posteriorly bicarinated, the concentric liræ becoming very rough and distinct at the posterior angle.

Rare, only one or two specimens.

TELLINA (MÆRA) LECHRIOGRAMMA, *sp. nov.* (Pl. 1, f. 22).

T. testâ albidâ solidiusculâ, donaciformi, posticé abbreviatâ, subobliquâ, anticé elongatâ, undique concentricé tenui-liratâ, nitidâ.

Long. 14 mill.

Lat. 7 „

Hab. Bombay (*Abercrombie*).

Apparently not uncommon, but mostly in imperfect condition, half valves only. It is like *T. pygmæa* (Phil.) in shape, but of thicker consistency, pure shining white, very finely concentrically lirate, posteriorly abbreviate, anteriorly elongate, with some of the appearance of a *Mesodesma* or *Donacilla.*

THRACIA SALSETTENSIS, *sp. nov.* (Pl. 1, f. 24).

T. testâ pertenui, oblongâ, albâ, posticé flexuoso-quadratâ et subrostratâ, anticé ovato-oblongâ, valvâ sinistrâ subplanatâ, dextrâ convexa, valvis ambabus, præsertim sinistrâ, plicis concentricis undanter succinctis, posticé fere applanatis.

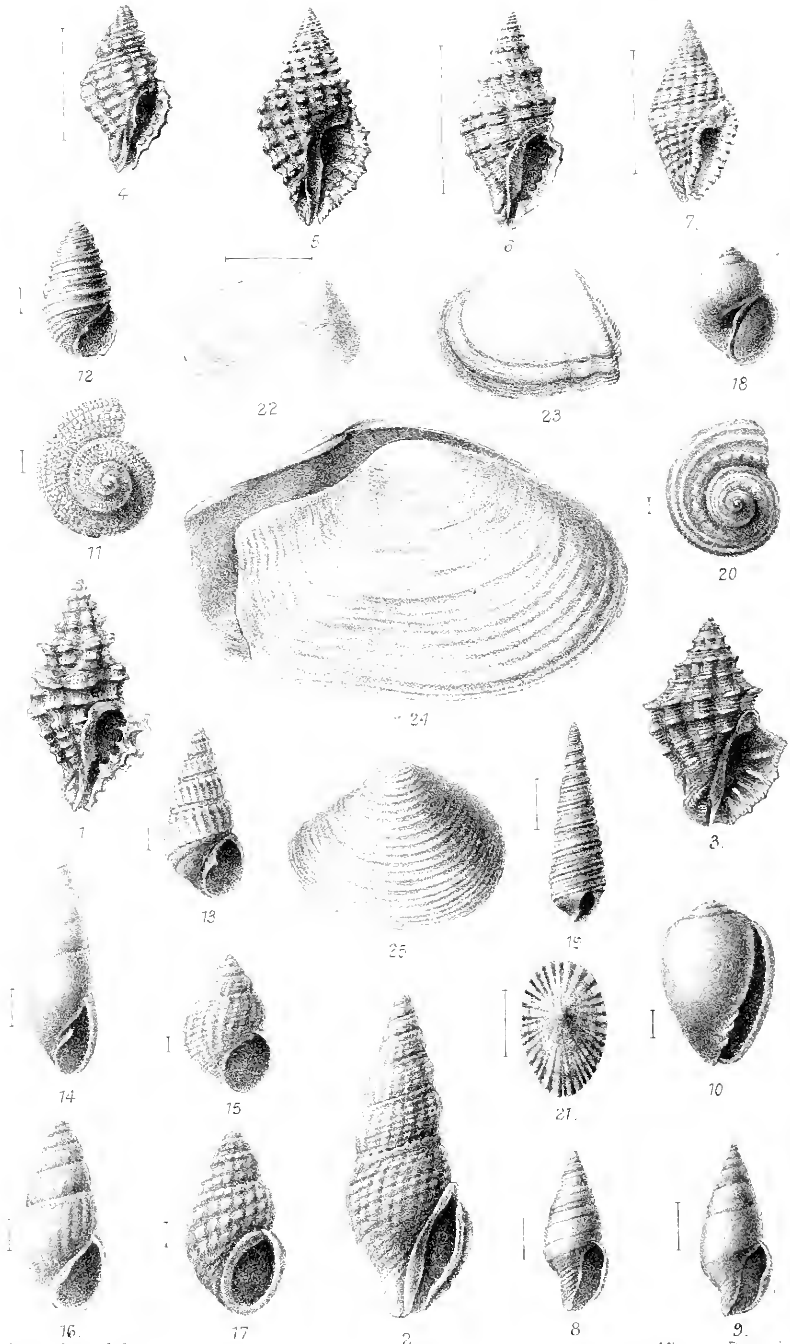
Long. 36 mill.

Lat. 52 „

Hab. Bombay (*Abercrombie*).

A remarkably delicate semi-trapezoid species, of which numerous single valves were found, but no quite perfect specimen. The left valve is almost flattened, with a broad longitudinal depression, inclining posteriorly, almost down the centre of the left valve from the umbo, the right being convex. Posteriorly in both valves, the shell is quadrato-rostrate, anteriorly oblong, the transverse wavy plicæ running concentrically shew this species to belong to that section of the genus of which at present there are only, including this new species, four representatives known to me, viz.: *T. magnifica* (Jonas), *T. plicata* (Desh.), and *T. granulosa* (Ad. and Reeve), the former of them being Californian, the latter Eastern species.

N.B.—The types of all the above mentioned new species have been deposited in the Mus. Brit., South Kensington.



J. Green del et lith. Mintern Bros. imp.

REFERENCES TO PLATE.

1. *Murex* (*Ocinebra*) *Bombayanus* (Melv.).
2. *Pleurotoma* (*Clavus*) *præclara* (Melv.).
3. *Purpura* (*Stramonita*) *Blanfordi* (Melv.).
4. *Ricinula* (*Sistrum*) *subnodulosa* (Melv.).
5. ,, (,,) *Konkanensis* (Melv.).
6. ,, (,,) *xuthedra* (Melv.).
7. *Engina zea* (Melv.).
8. *Columbella* (*Mitrella*) *flavilinea* (Melv.).
9. ,, (,,) *Euterpe* (Melv.).
10. *Marginella* (*Gibberula*) *Mazagonica* (Melv.).
11. *Solarium* (*Torinia*) *delectabile* (Melv.).
12. *Oscilla tornata* (A. Adams. *sp. inedit*) (Melv.).
13. *Pyrgulina callista* (Melv.).
14. *Amathis filia* (Melv.).
15. *Rissoa Versoverana* (Melv.).
16. *Rissoina* (*Zebina*) *applanata* (Melv.).
17. *Alvania Mahimensis* (Melv.).
18. *Naticina pomatiella* (Melv.).
19. *Cerithiopsis* (*Seila*) *Bandorensis* (Melv.).
20. *Cyclostrema solariellum* (Melv.).
21. *Siphonaria Basseinensis* (Melv.).
22. *Tellina* (*Mœra*) *lechriogramma* (Melv.).
23. ,, *Kolabana* (Melv.).
24. *Thracia Salsettensis* (Melv.).
25. *Raeta Abercrombiei* (Melv.).

General Meeting, November 29th, 1892.

Professor OSBORNE REYNOLDS, LL.D., F.R.S., Vice-President, in the Chair.

The Rev. EDWARD LEE HICKS, M.A., Canon of Manchester, Rector of St. Philip's, Salford; and Mr. RUPERT SWINDELLS, M.Inst.C.E., Wilton Villa, The Firs, Bowdon, were elected ordinary members.

Ordinary Meeting, November 29th, 1892.

Professor A. SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Professor H. B. DIXON, M.A., F.R.S., read a paper "On the Rate of Explosion in Gases." A discussion followed, in which Professor REYNOLDS, Dr. BOTTOMLEY, and others took part.

Ordinary Meeting, December 13th, 1892.

EDWARD SCHUNCK, Ph.D., F.R.S., F.C.S., Vice-President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Referring to the portrait of Mr. Baxendell, which was again exhibited, and for the purchase of which additional subscriptions were promised, and to the portraits of deceased members generally, Dr. BOTTOMLEY pointed out that, without some published record, there might arise future confusion, from the fact that in the Council Room of the Society there were two portraits of George Walker. The largest one represented the Rev. George Walker, F.R.S., elected a member in 1798, and president in 1805, who died at Wavertree, near Liverpool, April 10th, 1807, aged 71. The miniature portrait represented Mr. George Walker, whose manuscript journal was presented in 1870 to the Society, by Mr. B. H. Green, through Mr. E. W. Binney, who had occasionally published extracts from it in the *Proceedings*, relative to the importation of cotton. On the miniature, Mr. Walker is described as one of the founders of the Society, though his election (Jany. 30th, 1782) was somewhat later than the date of foundation (Feb. 28th, 1781) stated on the diplomas of the Society.

Referring to Mr. BROCKBANK'S paper on "The Artificial Colouration of Plants," Dr. SCHUNCK exhibited a paper by Professor Auger, of Vienna in which was described, in 1848, the artificial colouring of plants by taking up mineral colouring matter, and the consequent injury to the plants. Dr. HODGKINSON, Mr. CHARLES BAILEY, Mr. HOYLE, and Mr. ASHWORTH took part in the discussion.

Mr. W. E HOYLE, M.A., exhibited *Nautilus pompilius* (the Pearly Nautilus) and *Notoryctes typhlops* (the burrowing marsupial).

Mr. WILLIAM THOMSON, F.R.S.Ed., F.C.S., read a paper "On the Suspended Impurities in Manchester Water," relating to the separation of solid matter from the water by means of a filter of fossil earth. A discussion ensued, in which Professor REYNOLDS and Dr. SCHUNCK took part.

Ordinary Meeting, December 27th, 1892.

CHARLES BAILEY, F.L.S., Treasurer, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Reference was made to the death of Sir RICHARD OWEN, F.R.S., F.L.S., &c., &c., who was elected an honorary member of the Society in 1844.

Dr. JAMES BOTTOMLEY, F.C.S., read a paper "On a Method of Integration applicable to certain partial Differential Equations."

A conversation on various simplified methods of obtaining mathematical, and particularly arithmetical, results ensued.

General Meeting, January 10th, 1893.

Professor A. SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

Mr. W. J. CHADWICK, Optician, 2, St. Mary's Street, Manchester, was elected an ordinary member.

Ordinary Meeting, January 10th, 1893.

Professor A. SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

A conversation on alternations of temperature on high mountains followed an inquiry from Dr. HODGKINSON as to the proper method of treating a consignment of orchids from an elevation of 9,000 feet in the tropical Andes. Professor SCHUSTER pointed out that it would be necessary to know the exact locality before forming an opinion, as within comparatively short distances there are great differences in the rainfall on high mountains, as, for instance, between the northern and southern slopes of the Himalayas, and great daily variations of temperature.

Professor SCHUSTER alluded to the recent announcement that black diamonds had been discovered distributed through meteoric iron, and Dr. REYNOLDS suggested a relation between them and apparently analogous formations in cast iron.

Ordinary Meeting, January 24th, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. F. J. FARADAY, F.L.S., called attention to a paper by Dr. Ferdinand Cohn, read before the Breslau Kaiserlichen Leopoldinisch-Carolinischen Akademie der Naturforscher on November 15, 1856, and published in Part 1, Vol. XXVI. of the *Verhandlungen*, describing the effects of lightning strokes on pine trees. The special observations referred to were that the stroke either attacks the summit of the tree, or some conspicuous point lower down the trunk; that the main current is conducted through the cambial layer; that the bark and bast are blown off by the sudden heating and vaporisation of the moisture in the cambium cells; that the stripping of the bark is not necessarily an indication of the course of the current, but occurs only in those places where the bark offers the least resistance to the force of the explosion; that the splitting of the tree and stripping of the bark tend to take a spiral direction in conformity with the spiral growth of the tree; that all trees may be struck, but that some are struck more frequently than others; and that the effects of the stroke depend rather on the intensity of the current than on the nature of the tree. A case was mentioned where a huge splinter from the summit of a pine tree was found in a cleft of the lower part of the trunk produced by the same stroke, indicating that the current passed more rapidly than the splinter fell.

Professor F. E. WEISS gave an account of Mr. Tonesco's recent paper on "The Damage by Lightning to Trees," published in the *Yahresheft des Vereins fur vaterländisch Naturkunde in Würtemburg*, 1893. Mr. Tonesco's conclusions are that the amount of water contained in the wood of various trees does not cause the difference in liability to be struck, which is noticeable in trees, but that the presence or absence of oil in the wood is the chief cause of this difference. Fischer had shown (*Pringsheim's Yahrbuch*, 1891) that the reserve starch contained in the wood is in many trees converted into oil, which, being a bad conductor, protects these trees from lightning, which would select those trees which are the best conductors. Thus beeches, in which oil is present in large quantities, are very rarely struck by lightning, while oaks are, perhaps, the most frequently damaged by this cause. Among the conifers the Scotch fir, in which the oil disappears in the summer, is more liable to be struck than the stone pine, in which a considerable oil remains in the summer. For these reasons trees are worse conductors in the winter than in the summer, and are also less frequently injured by lightning in winter thunderstorms than in those taking place in the summer. The course taken by the lightning is, as Cohn had shown, along the cambium, which, containing most water, is the best conductor. The substratum on which the trees are growing is in no direct connection with the frequency of injuries by lightning. The leafy portion of trees, being a bad conductor, is usually not struck, the lightning striking below the main branches, but if the leaves have been thoroughly wetted the lightning often strikes this upper portion of the tree. Dead branches seem to attract the lightning most frequently, both in trees which are rich in oil, and such as are poor in that substance.

Dr. G. H. BAILEY remarked that pines appeared to be peculiarly liable to lightning strokes, and Dr. BOTTOMLEY suggested that this might be a consequence of the pointed form of the leaves.

The PRESIDENT (Dr. SCHUSTER) remarked that the oil and the water theories might be reconciled. Whether a tree is struck by lightning or not may be determined by the amount of oily matter it contains; but once a tree is struck the discharge will chiefly pass through the moisture, and the damage will be greatest in those layers which contain the greatest amount of moisture. He also alluded to communications on the subject made to the Society in 1873 by the late Mr. Baxendell, and to experiments performed at that time by Professor REYNOLDS to test the explosive force of small quantities of moisture volatilised by the electric spark, the results of which were communicated to the Society in the same year.

Dr. JAMES BOTTOMLEY read an additional note to his paper on "A method of Integration applicable to certain partial Differential Equations."

Dr. SCHUSTER, F.R.S., read the following "Note on Accurate Weighing":—

"Two methods are generally given to determine the mass of a body when great accuracy is required. One is Borda's method of substitution, the other is generally ascribed to Gauss, and may be referred to here as that of interchanging weights. The methods, really identical in principle, are too well known to need further description. The present note refers to the method of double weighing, which is above criticism in itself, but the way in which it is generally explained seems to me to be defective, and the practice of the method as given in several standard treatises on practical physics is faulty in so far as it involves one weighing which is useless, and causes, therefore, loss of time, which may be better employed in otherwise increasing the accuracy of the determination. Let M be the mass of the body required, the operator is instructed to find the apparent weight when it is placed on one side of the balance, say P, to repeat the weighing when the body is on the other side of the balance (Q), and then if a and b are the arms of the balance, it is stated that

$$Ma = Pb$$
$$Mb = Qa$$

and hence

$$M = \sqrt{PQ} = \tfrac{1}{2}(P + Q)$$

if P and Q are nearly equal.

If the whole balance were perfectly rigid in all its parts, this deduction would be correct; but the balances as constructed shew a very appreciable bending of the beam, and it is not correct to assume that the bending is the same on both sides.

"Now, how is the so-called apparent weight of the body, when placed on one side of the balance, determined? The position of rest of the balance when unloaded is first obtained, and then with the body in one of the pans that weight is found which brings the balance back to the same position. It is the object of this note to point out that the position of rest of an unloaded balance has nothing to do with the behaviour of the balance when it is loaded, for the centre of gravity of the beam and pan may be displaced by the load. The so-called zero of the balance is a matter of no importance, and need therefore not be observed at all. If the practice of the method gives the correct result, it is only because this zero disappears from the result. Let θ_0 be the position of rest of the unloaded balance, and let θ_1 be that position of rest to which the balance will come when two equal masses M are placed on it, also let W be the weight required to charge the zero through one division under the given circumstances, then the quantity called P above would be $M + W(\theta_1 - \theta_0)$ and the quantity Q would be $M - W(\theta_1 - \theta_0)$. Hence W would be correctly obtained by taking the arithmetical mean of P and Q, but the same would be true if we substitute for the value of θ_0 any scale division, say the central one, and the labour of finding θ_0 is wasted. The sole test of equality of weights is that one may be replaced by the other without change in the position of rest. If two weights are interchanged, and the balance vibrates about the same point, the weights are equal. This suggests the following method of procedure :—With the unknown mass on one side, place weights P on the other until the balance swings about some point not far removed from the central position, or, better still, about that point at which previous experience has shown the balance would come to rest with equal loads of approximately the value of M. Let θ_1 be the observed position. Interchange the two masses without alteration of P. The position of equilibrium will be slightly different, say θ_2. It follows that the position of rest for equal weights is $(\theta_1 + \theta_2)/2$, and if W is the weight required to produce a change of one division the required mass of M differs from P by $W.\frac{\theta_1 - \theta_2}{2}$. Whether P is larger or smaller than M is easily seen from the weighings. This method has been followed in the Physical Laboratory of the Owens College during the last two years with good results. Its accuracy may of course be increased by repeating the interchange of weights. Sufficient experience has not yet been gained as to the most accurate way of obtaining the value denoted by W. The method of interchanging weights has, as far as I know, been first used in accurate weighing by Miller in his researches on the standard pound, and he gives Steinheil as his authority for ascribing the method to Gauss. But I could find no reference to the subject in any of Gauss' papers. On the other hand, I have found a description of the method without its being ascribed to any particular person in Fischer's *Physikalisches Wörterbuch*, which was published in 1804. Gauss was then 27 years old, and had already published his famous *Disquisitones arithmeticae*, but as far as the record of his published researches goes, he had devoted himself altogether to the subject of pure mathematics until a much later period. It seems, therefore, very unlikely that he is the inventor of a method which probably is much older, but which curiously was left unnoticed by most writers until Miller revived its use. In Biot's *Traité de Physique*, Borda's method is mentioned as the only one which eliminates the errors of the balance, and similarly Kaemtz (1839), Lamé (1840), Ettinghausen (1845) and Péclet only refer to Borda's method. If, therefore, it is desired to attach any name to the method it should be Miller's, who brought it into general use."

On a Method of Integration applicable to certain partial Differential Equations. By James Bottomley, D.Sc., &c.

(Received December 27th, 1892.)

In this paper is proposed a method of integration applicable to certain partial differential equations, which, possibly, has not been previously noticed, and seems to have the merit of simplicity, also the advantage of being applicable to some equations of high order, even where the general theory belonging to equations of that order has not been investigated.

The method, shortly stated, depends on the fact that when a function of several variables is differentiated with regard to all those variables, the final result is independent of the order in which these operations are performed; by the addition of these identical results to certain partial differential equations, we obtain equations which admit of being expressed as equations of lower order. As an example of the method, consider the equation—

$$\frac{d^2z}{dx^2}=\frac{d^2z}{dy^2}; \quad . \quad . \quad . \quad . \quad (1)$$

then the subsidiary equation will be

$$\frac{d^2z}{dxdy}=\frac{d^2z}{dydx}; \quad . \quad . \quad . \quad . \quad (2)$$

by addition we get

$$\frac{d^2z}{dx^2}+\frac{d^2z}{dxdy}=\frac{d^2z}{dy^2}+\frac{d^2z}{dydx}, \quad . \quad . \quad . \quad (3)$$

but each side of this equation is a complete differential, for we may write it in the form

$$\frac{d}{dx}\left(\frac{dz}{dx}+\frac{dz}{dy}\right)=\frac{d}{dy}\left(\frac{dz}{dy}+\frac{dz}{dx}\right); \quad . \quad . \quad (4)$$

or more briefly in the form

$$\frac{dv}{dx}=\frac{dv}{dy}; \quad . \quad . \quad . \quad . \quad (5)$$

wherein v has been substituted for the expression in brackets in (4).

Hence equation (1) has been reduced in form to one of the first order. Since v is a function of $\frac{dz}{dx}$ and $\frac{dz}{dy}$, it will be a function of x and y, therefore we shall have the equation

$$dv=\frac{dv}{dx}dx+\frac{dv}{dy}dy. \quad . \quad . \quad . \quad (6)$$

Proceeding in the ordinary way, we shall obtain the equation

$$v=\phi(x+y); \quad . \quad . \quad . \quad . \quad (7)$$

or by substitution

$$\frac{dz}{dx}+\frac{dz}{dy}=\phi(x+y); \quad . \quad . \quad . \quad (8)$$

ϕ denoting an arbitrary function. From this equation we obtain

$$z=\phi_1(x+y)+\phi_2(y-x) \quad . \quad . \quad . \quad (9)$$

This method of procedure may also be applied indirectly to the integration of the equation which has such extensive physical application:

$$\frac{d^2z}{dx^2}=a^2\frac{d^2z}{dy^2}. \quad . \quad . \quad . \quad (10)$$

For x substitute a new variable ξ so that the two are connected by the equation

$$\xi=ax, \quad . \quad . \quad . \quad . \quad (11)$$

hence, we have

$$\frac{dz}{dx}=\frac{dz}{d\xi}\frac{d\xi}{dx}=a\frac{dz}{d\xi}; \text{ and } \frac{d^2z}{dx^2}=\frac{d}{dx}a\frac{dz}{d\xi}=a^2\frac{d^2z}{d\xi^2}$$

substituting in (10) we obtain the equation

$$\frac{d^2z}{d\xi^2}=\frac{d^2z}{dy^2}; \quad . \quad . \quad . \quad . \quad (12)$$

the integral of which has been obtained already, so that it is only necessary to make in that equation the substitution indicated in (11).

As an example of the application of the method to an equation of higher order than the second, consider the equation,

$$\frac{d^4 z}{dx^4} = \frac{d^4 z}{dy^4}. \quad . \quad . \quad . \quad . \quad (13)$$

If, then, we differentiate z four times, twice with regard to x and twice with regard to y, since the result is independent of the order of the operations, the subsidiary equation will be

$$\frac{d^4 z}{dx^2 dy^2} = \frac{d^4 z}{dy^2 dx^2}; \quad . \quad . \quad . \quad (14)$$

hence, by addition,

$$\frac{d^4 z}{dx^4} + \frac{d^4 z}{dx^2 dy^2} = \frac{d^4 z}{dy^4} + \frac{d^4 z}{dy^2 dx^2}. \quad . \quad . \quad (15)$$

But each side is now a complete differential, for we may write the equation in the form

$$\frac{d^2}{dx^2}\left(\frac{d^2 z}{dx^2} + \frac{d^2 z}{dy^2}\right) = \frac{d^2}{dy^2}\left(\frac{d^2 z}{dy^2} + \frac{d^2 z}{dx^2}\right). \quad . \quad . \quad (16)$$

Now assume

$$v = \frac{d^2 z}{dx^2} + \frac{d^2 z}{dy^2}; \quad . \quad . \quad . \quad . \quad (17)$$

then (16) may be written in the form

$$\frac{d^2 v}{dx^2} = \frac{d^2 v}{dy^2}. \quad . \quad . \quad . \quad . \quad (18)$$

Hence, by this method we have reduced an equation of the fourth order to one of the second order, and by means of the equation

$$\frac{d^2 v}{dxdy} = \frac{d^2 v}{dydx}, \quad . \quad . \quad . \quad . \quad (19)$$

equation (18) may be presented in the form

$$\frac{d}{dx}\left(\frac{dv}{dx} + \frac{dv}{dy}\right) = \frac{d}{dy}\left(\frac{dv}{dy} + \frac{dv}{dx}\right), \quad . \quad . \quad (20)$$

and if we assume

$$v = \frac{dv}{dx} + \frac{dv}{dy}, \quad . \quad . \quad (21)$$

then (20) may be written in the form

$$\frac{dv}{dx} = \frac{dv}{dy}: \quad . \quad . \quad . \quad . \quad (22)$$

therefore, by this method we have succeeded in reducing an equation of the fourth order to one of the first order; v will be a function of x and y; therefore, following the usual method, the integral of the last equation will be

$$v = \phi_1(x + y), \quad . \quad . \quad . \quad . \quad (23)$$

or by substitution from (21)

$$\frac{dv}{dx} + \frac{dv}{dy} = \phi_1(x + y). \quad . \quad . \quad . \quad (24)$$

Integrating a second time we obtain,

$$v = \phi_2(y + x) + \phi_3(y - x) \quad . \quad . \quad . \quad (25)$$

Substituting for v its value given by (17), the last equation may be put in the form

$$\frac{d^2z}{dx^2} = -\frac{d^2z}{dy^2} + \phi_2(y + x) + \phi_3(y - x) \quad . \quad . \quad (26)$$

In order to continue the application of the method at this stage a change of one of the variables must be made; assume the equation

$$x = \sqrt{-1}\,\xi. \quad . \quad . \quad . \quad . \quad (27)$$

By means of this equation we obtain

$$\frac{d^2z}{dx^2} = -\frac{d^2z}{d\xi^2} \quad . \quad . \quad . \quad . \quad (28)$$

Substituting in (26) we obtain

$$\frac{d^2z}{d\xi^2} = \frac{d^2z}{dy^2} - \phi_2(y + \sqrt{-1}\,\xi) - \phi_3(y - \sqrt{-1}\,\xi) \quad . \quad (29)$$

The auxiliary equation will therefore be

$$\frac{d^2z}{d\xi dy} = \frac{d^2z}{dy d\xi}, \quad . \quad . \quad . \quad . \quad (30)$$

and proceeding as before we get the equation

$$\frac{dz}{d\xi}+\frac{dz}{dy}=\phi_4(y+\xi)+\phi_5(y+\sqrt{-1}\xi)+\phi_6(y-\sqrt{-1}\xi) \quad . \ (31)$$

Integrating this equation and substituting for ξ we obtain finally

$$z=\phi_7(y+x)+\phi_8(y-x)+\phi_9(y+\sqrt{-1}.x)+\phi_{10}(y-\sqrt{-1}.x) \quad (32)$$

The above method may now be applied to the equation

$$\frac{d^4z}{dx^4}=a^4\frac{d^4z}{dy^4} \quad . \quad . \quad . \quad . \ (33)$$

Assume the equation

$$ax=\xi \ . \quad . \quad . \quad . \quad . \ (34)$$

Then changing the variable we shall obtain

$$\frac{d^4z}{dx^4}=a^4\frac{d^4z}{d\xi^4}. \quad . \quad . \quad . \quad . \ (35)$$

Substituting in (33) we obtain

$$\frac{d^4z}{d\xi^4}=\frac{d^4z}{dy^4}\ ; \quad . \quad . \quad . \quad . \ (36)$$

the integration of which has just been effected; hence the integral of (33) will be obtained by writing ax for x in (32).

Next, consider the equation of the order 2^{n+1}

$$\left(\frac{d}{dx}\right)^{2^n+1}_{z_1}=\left(\frac{d}{dy}\right)^{2^n+1}_{z_1} \quad . \quad . \quad . \ (37)$$

The auxiliary equation will be

$$\left(\frac{d^2}{dxdy}\right)^{2^n}_{z_1}=\left(\frac{d^2}{dydx}\right)^{2^n}_{z}, \quad . \quad . \quad . \ (38)$$

by addition we obtain

$$\left(\frac{d^2}{dx^2}\right)^{n}_{z_1}+\left(\frac{d^2}{dxdy}\right)^{2^n}_{z_1}=\left(\frac{d^2}{dy^2}\right)^{2^n}_{z_1}+\left(\frac{d^2}{dydx}\right)^{2^n}_{z_1}. \quad . \ (39)$$

but each side may now be written as a complete differential, for it may be put in the form

$$\frac{d^{2^n}}{dx^{2^n}}\left(\frac{d^{2^n}z_1}{dx^{2^n}}+\frac{d^{2^n}z_1}{dy^{2^n}}\right)=\frac{d^{2^n}}{dy^{2^n}}\left(\frac{d^{2^n}z_1}{dy^{2^n}}+\frac{d^{2^n}z_1}{dx^{2^n}}\right); \ . \quad . \ (40)$$

or assuming

$$z_2 = \frac{d^{2^n} z_1}{dx^{2^n}} + \frac{d^{2^n} z_1}{dy^{2^n}}, \qquad . \quad (41)$$

we obtain

$$\left(\frac{d}{dx}\right)^{2^n} z_2 = \left(\frac{d}{dy}\right)^{2^n} z_2. \qquad . \quad . \quad . \quad (42)$$

Therefore an equation of the order 2^{n+1} has been reduced to one of the order 2^n. Then by addition to the last equation of the auxiliary equation

$$\left(\frac{d^2}{dxdy}\right)^{2^{n-1}} z_2 = \left(\frac{d^2}{dydx}\right)^{2^{n-1}} z_2 \qquad . \quad . \quad . \quad (43)$$

we obtain an equation which may be written in the form

$$\frac{d^{2^{n-1}}}{dx^{2^{n-1}}}\left(\frac{d^{2^{n-1}} z_2}{dx^{2^{n-1}}} + \frac{d^{2^{n-1}} z_2}{dy^{2^{n-1}}}\right) = \frac{d^{2^{n-1}}}{dy^{2^{n-1}}}\left(\frac{d^{2^{n-1}} z_2}{dy^{2^{n-1}}} + \frac{d^{2^{n-1}} z_2}{dx^{2^{n-1}}}\right). \quad (44)$$

or assuming

$$z_3 = \frac{d^{2^{n-1}} z_2}{dx^{2^{n-1}}} + \frac{d^{2^{n-1}} z_2}{dy^{2^{n-1}}}, \qquad . \quad . \quad . \quad (45)$$

we may write

$$\frac{d^{2^{n-1}}}{dx^{2^{n-1}}} = \frac{d^{2^{n-1}} z_3}{dy^{2^{n-1}}} \qquad . \quad . \quad . \quad . \quad (46)$$

Therefore by the application of the method we have reduced an equation of the order 2^{n+1} to one of the order 2^{n-1}. It is evident that by the aid of the successive auxiliary equations we shall finally obtain an equation of the first order of the form

$$\frac{dz_{2^n+1}}{dx} = \frac{dz_{2^n+1}}{dy}; \qquad . \quad . \quad . \quad . \quad (47)$$

of which the integral is

$$z_{2^n+1} = \phi_1(x+y). \qquad . \quad . \quad . \quad (48)$$

By substitution we should get another equation of the first order of the form,

$$\frac{dz_{2^n}}{dx} + \frac{dz_{2^n}}{dy} = \phi_1(x+y), \qquad . \quad . \quad . \quad (49)$$

of which the integral is

$$z_{2n} = \phi_2(y+x) + \phi_3(y-x) \quad . \quad . \quad . \quad (50)$$

If we substitute for z_{2n} the differential expression for which it stands, we shall obtain a differential equation of the second order, but by repeated applications of the method this and all succeeding equations may be reduced and integrated as equations of the first order in the manner indicated in the treatment of the equation of the fourth order (13), and finally we shall obtain as the solution of the equation (37) the expression

$$z_1 = f_1(y+\rho_1 x) + f_2(y+\rho_2 x) + f_3(y+\rho_3 x) + \ . \ . \ . \ f_{2^n+1}(y+\rho_{2^n+1}x), \quad (51)$$

where the letters $f_1, f_2 \ldots . f_{2^n+1}$, denote arbitrary functions, and the letters $\rho_1\ \rho_2\ \rho_3 \ldots . \rho_{2^n+1}$ are the roots of the equation

$$\chi^{2^n+1} - 1 = 0 \quad . \quad . \quad . \quad . \quad (52)$$

The foregoing method may also be used to integrate the equation

$$\left(\frac{d}{dx}\right)^{2^n+1} z = a\left(\frac{d}{dy}\right)^{2^n+1} z \quad . \quad . \quad . \quad (53)$$

assume the equation

$$\xi = \rho x \quad . \quad . \quad . \quad . \quad (54)$$

where ρ denotes a root of the equation

$$\chi^{2^n+1} - a = 0 \quad . \quad . \quad . \quad . \quad (55)$$

Then if we differentiate 2^{n+} times we shall obtain

$$\left(\frac{d}{dx}\right)^{2^n+1} z = a\left(\frac{d}{d\xi}\right)^{2^n+1} z \quad . \quad . \quad . \quad (56)$$

hence by substitution in (53) we shall get

$$\left(\frac{d}{d\xi}\right)^{2^n+1} z = \left(\frac{d}{dy}\right)^{2^n+1} z,$$

of which the mode of integrating has already been given.

All the equations considered are of an even order, and on reduction give rise to equations of even order until we arrive at an equation of the first order; but in equation (53), if for 2^{n+1}, we write $m2^{n+1}$, where m denotes an odd number, there the method may be used to reduce an equation of the order $m2^{n+}$ to one of the order m.

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(Additional Note received January 24th, 1893.)

In the former portion of the paper I suggested, for reducing and integrating certain partial differential equations, a method which did not require a knowledge of the general law of integration of equations of that order. In this additional note I wish to point out that if in line 12 of the previous paper we substitute subtraction for addition we shall still obtain integrable forms. As a particular example consider (1) and subtract from it (2) then we shall obtain the equation

$$\frac{d^2z}{dx^2} - \frac{d^2z}{dxdy} = \frac{d^2z}{dy^2} - \frac{d^2z}{dydx}$$

but this may be written in the form

$$\frac{d}{dx}\left(\frac{dz}{dx} - \frac{dz}{dy}\right) = -\frac{d}{dy}\left(\frac{dz}{dx} - \frac{dz}{dy}\right),$$

of which the integral obtained in the ordinary way is

$$\frac{dz}{dx} - \frac{dz}{dy} = \phi_2(y - x).$$

By means of (8) and the present equation, equation (9) may be obtained in the usual manner.

Next consider the equation of the 4th order (13); if from this we subtract the auxiliary equation (14), we obtain a result which may be written in the form,

$$\frac{d^2v}{dx^2} = -\frac{d^2v}{dy^2}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (57)$$

wherein

$$v = \frac{d^2z}{dx^2} - \frac{d^2z}{dy^2}.$$

To integrate (57) by the proposed method assume the equation

$$\xi = x\sqrt{-1}\,;$$

then changing the variable (57) becomes

$$\frac{d^2v}{d\xi^2} = \frac{d^2v}{dy^2}\,;$$

of which the integral as obtained by the method is

$$v = \phi_4(y+\xi) + \phi_5(y-\xi)\,;$$

or by substitution,

$$\frac{d^2z}{dx^2} - \frac{d^2z}{dy^2} = \phi_4(y + x\sqrt{-1}) + \phi_5(y - x\sqrt{-1}). \quad . \quad (58)$$

Hence by the addition of (58) and (26) we obtain,

$$2\frac{d^2z}{dx^2} = \phi_2(y+x) + \phi_3(y-x) + \phi_4(y + x\sqrt{-1}) + \phi_5(y - x\sqrt{-1}),$$

and by substraction of (58) from (26) we obtain

$$2\frac{d^2z}{dy^2} = \phi_2(y+x) + \phi_3(y-x) - \phi_4(y + x\sqrt{-1}) - \phi_5(y - x\sqrt{-1}).$$

Thus we have obtained two integrable equations; if from these we obtain $\frac{dz}{dx}$ and $\frac{dz}{dy}$, then these values along with the equation

$$dz = \frac{dz}{dx}dx + \frac{dz}{dy}dy,$$

will give on integration equation (32).

In previous examples before applying the method, a change of one of the variables has occasionally been made; the method, however, admits of some modification which renders such change unnecessary. For example consider the equation

$$\frac{d^2z}{dx^2} = a^2\frac{d^2z}{dy^2},$$

and let the auxiliary equation be

$$c\frac{d^2z}{dxdy} = c\frac{d^2z}{dydx},$$

the letter c denoting some quantity as yet undetermined; then by addition we obtain an equation which may be presented in the form,

$$\frac{d}{dx}\left(\frac{dz}{dx}+c\frac{dz}{dy}\right)=\frac{d}{dy}\left(\frac{a^2 dz}{dy}+c\frac{dz}{dx}\right),$$

or as it may be written

$$\frac{d}{dx}\left(\frac{dz}{dx}+c\frac{dz}{dy}\right)=c\frac{d}{dy}\left(\frac{a^2}{c}\frac{dz}{dy}+\frac{dz}{dx}\right),$$

now let c be so determined as to make the coefficients of $\frac{dz}{dy}$ on each side equal, then the equation may be written in the form

$$\frac{dv}{dx}=c\frac{dv}{dy}, \qquad \text{. . . . . . .} \qquad (59)$$

wherein

$$v=\frac{dz}{dx}+c\frac{dz}{dy},$$

and also

$$c=\frac{a^2}{c};$$

the last equation gives for c, the values $+a$ and $-a$. Integrating (59) and giving for v its value we have

$$\frac{dz}{dx}+c\frac{dz}{dy}=\phi(y+cx);$$

and substituting for c its two values we have

$$\frac{dz}{dx}+a\frac{dz}{dy}=\phi_1(y+ax)$$

$$\frac{dz}{dx}-a\frac{dz}{dy}=\phi_2(y-ax)$$

and the rest of the operation may be continued as usual.

The method of integration suggested in this paper admits of more general application than has previously been considered, and may be applied to some equations which are not of the general type already considered. For instance take the equation

$$\frac{d^2z}{dx^2}=a\frac{d^2z}{dy^2}+b\frac{d^2z}{dydx}$$

let the auxiliary equation be

$$c\frac{d^2z}{dxdy} = c\frac{d^2z}{dydx}$$

c being some undetermined quantity, if these equations be added the result may be put in the form

$$\frac{d}{dx}\left(\frac{dz}{dx} + c\frac{dz}{dy}\right) = \frac{d}{dy}\left(a\frac{dz}{dy} + (b+c)\frac{dz}{dx}\right),$$

or in the form

$$\frac{d}{dx}\left(\frac{dz}{dx} + c\frac{dz}{dy}\right) = (b+c)\frac{d}{dy}\left(\frac{a}{b+c}\frac{dz}{dy} + \frac{dz}{dx}\right). \quad . \quad (60)$$

Now let c be so determined that the coefficients of $\frac{dz}{dy}$ on both sides are equal; this implies the equation

$$c = \frac{a}{b+c}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (61)$$

Then (60) may be written in the form

$$\frac{dv}{dx} = \frac{a}{c}\frac{dv}{dy}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (62)$$

wherein

$$v = \frac{dz}{dx} + c\frac{dz}{dy}.$$

Hence if we integrate (62), and substitute for v, we shall obtain

$$\frac{dz}{dx} + c\frac{dz}{dy} = \phi\left(\frac{a}{c}x + y\right);$$

also from (61) we shall obtain the equation

$$c = -\frac{b}{2} \pm \sqrt{a + \frac{b^2}{4}},$$

hence if for c we substitute its two values we shall have two equations and two arbitrary functions, hence from these the values of $\frac{dz}{dx}$ and $\frac{dz}{dy}$ may be determined, and the integration completed.

General Meeting, February 7th, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

WILLIAM CRAWFORD WILLIAMSON, M.R.C.S., F.R.S., LL.D., &c., Past President of the Society, now of London, was elected an honorary member.

Ordinary Meeting, February 7th, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. FRANCIS JONES, F.R.S. Ed., F.C.S., and Mr. HARRY GRIMSHAW, F.C.S., were appointed auditors of the Society's accounts for the current year.

A letter from Mr. THOMAS KAY, enclosing slender filaments of wood from an oak tree at the Wood Farm, Torkington, near Stockport, the upper portion of which was shattered into such filaments by a stroke of lightning, was read.

Mr. C. S. TRAPP exhibited a specimen of lead pipe laid along grass fields many years ago for the conveyance of water from a spring. The pipe was remarkably eroded on the under surface, the upper surface and the interior being unaffected. The erosion was continuous for the length of two fields. A discussion on the possible cause of the phenomenon ensued, in which Mr. W. THOMSON, Mr. H. GRIMSHAW, and Professor REYNOLDS took part. It was suggested that the erosion might be due to the attacks of rats, to the perforation of a weak point in the pipes in consequence of impurities in the water, and the subsequent action of running water forcing a channel below, and to possible galvanic action resulting from contact with matters in the soil. The apparent absence of erosion in the interior of the pipe was referred to as evidence against the erosive action of impurities in the water.

The introduction to Part II. of Dr. W. C. WILLIAMSON'S "General, Morphological, and Histological Index to the Author's Collective Memoirs on the Fossil Plants of the Coal Measures" was read.

Mr. HARRY GRIMSHAW, F.C.S., read a paper on "Recent Developments in the application of Iron Salts to the Precipitation of Sewage." A discussion ensued, in which Mr. W. THOMSON, Dr. G. H. BAILEY and Mr. FARADAY took part.

General, Morphological, and Histological Index to the Author's Collective Memoirs on the Fossil Plants of the Coal Measures. Part II. By William Crawford Williamson, LL.D., F.R.S., &c., Foreign Member of the Royal Swedish Academy; Corresponding Member of the Royal Society of Göttingen, and of the Queckett Microscopical Club; Honorary Fellow of the Royal Microscopical Society of London; Honorary Member of the Physical and Natural History Society of Geneva; of the Literary and Philosophical Societies of Manchester, Scarborough, and Whitby; of the Geological Society of Manchester; of the Geological and Polytechnic Society of Yorkshire; of the Union of the Yorkshire Naturalists, and of the Field Naturalists' Societies of Liverpool, Scarborough, and Manchester; and Emeritus Professor of Botany in the Owens College, Manchester.

[*Received February 7th, 1893.*]

LIST OF WORKS

ON THE ORGANISATION OF THE

FOSSIL PLANTS OF THE COAL MEASURES,

AND GENERAL INDEX TO THEIR CONTENTS.

ROYAL SOCIETY SERIES, I. TO XIX.

Symbols.	*Parts.*	
A.	I.	Calamites and suggested genus Calamopitus (not subsequently insisted upon). Figs. 16 and 17 do not belong to Calamites but to the subsequently adopted genus Astromyelon. *Phil. Trans.*, 1871.
B.	II.	Lepidodendron selaginoides, Diploxylon (Corda), Ulodendron, Favularia, Sigillaria, Stigmaria, Lepidodendroid Cone (?) ultimately Lepidodendron parvulum. (*Memoir* XVI.) Anabathra. *Phil. Trans.*, 1872.
C.	III.	Lepidodendron brevifolium. (Burntisland form) and its Lepidostrobus. Restoration of Lepidodendron. *Phil. Trans.*, 1872.

Symbols.	*Parts.*	
D.	IV.	Lyginodendron Oldhamium; Heterangium Grievii. *Phil. Trans.*, 1873.
E.	V.	Asterophyllites with Sphenophylloid axis. Sphenophyllum. Volkmannia (subsequently Bowmanites) Dawsoni, Strobilus of Asterophyllites (subsequently Paracalamostachys Williamsoniana; Weiss) Asterophyllites fruit (subsequently Palæostachya pedunculata. (See Weiss. Steinkohlen-Calamarien). Calamostachys Binneyana, Calamites verticillatus. Root of Asterophyllites (afterwards Amyelon). *Phil. Trans.*, 1874.
F.	VI.	Rachiopteris aspera (afterwards petiole of Lyginodendron Oldhamium) Rachiopteris Oldhamium, Rachiopteris duplex, Rachiopteris Lacattii, Rachiopteris bibractensis, Anachoropteris Decaisnii. *Phil. Trans.*, 1874.
G.	VII.	Myelopteris (Medullosa of Cotta), Psaronius Renaultii, Kaloxylon Hookeri. *Phil. Trans.*, 1876.
H.	VIII.	Rachiopteris corrugata, Fern Sporangia, Gymnospermæ-Dadoxylon, Gymnospermous Seeds, Lagenostoma ovoides, Lagenostoma physoides, Conostoma oblonga, Conostoma ovalis, Conostoma intermedia, Malacotesta oblonga, Trigonocarpon olivæforme, Hexapterospermun Nöggerathi-Cardiocarpon anomalum, Cardiocarpon compressum, Car, diocarpon acutum, Cardiocarpon Butterworthii, Polypterospermum. *Phil. Trans.*, 1877.
I.	IX.	Astromyelon, subsequently A. Williamsonis, Calamites, Asterophyllites, Lepidodendron selaginoides, Lepidostrobus, Macrospores, Rachiopteris rotundata, Rachiopteris cylindrica, Cordaites (?) epiderm, Lyginodendron (?) anomalum, Lepidodendroid cortex, Oidospora anomala, Volkmannia (?) parvula, Lepidodendron Spenceri. *Phil. Trans.*, 1878.
K.	X.	Arran Lepidodendron, subsequently L. Wunschianum, Lepidodendron Spenceri, Heterosporous Lepidostrobus, Calamostachys Binneyana, Rachiopteris insignis, Tylosis, Rachiopteris robusta, Sporocarpon elegans, Sporocarpon pachyderma, Sporocarpon asteroides, Sporocarpon ornatum, Traquaria, Zygosporites (subsequently shewn to be spores), Dadoxylon, Lagenostoma ovoides, Cardiocarpon anomalum, Calcisphæra (Radiolariæ of Judd). *Phil. Trans.*, 1880.
L.	XI.	Lepidodendron selaginoides, Lepidodendron Harcourtii. (The plant so named here is now designated L. fuliginosum. (See *Proceedings Royal Society*, Vol. XLII., p. 6). Stigmarian rootlets, Medullary rays of Lepidodendron selaginoides, Calamostachys Binneyana and C. Casheana, Fungi. *Phil. Trans.*, 1881.
M.	XII.	Astromyelon Williamsonis, Psaronius Renaultii, Zygosporites (in a Sporangium), Calamites, Lepidodendron, Halonia, Sporocarpon ornatum, Salisburia Adiantifolia. *Phil. Trans.*, 1881.
N.	XIII.	Heterangium Tiliæoides, Kaloxylon Hookeri. *Phil. Trans.*, 1887.
O.	XIV.	True fructification of Calamites. *Phil. Trans.*, 1888.
P.	XV.	Rachiopteris Grayii. Rachiopteris Lacattii; Calamostachys Binneyana, Rachiopteris hirsuta, Rhizonium verticillatum, Rhizonium reticulatum, Rhizonium lacunosum.

Symbols.	*Parts.*	
Q.	XVI.	Lepidodendron fuliginosum, Lepidodendron mundum, Lepidodendron Spenceri, Lepidodendron parvulum, Rachiopteris inæqualis. *Phil. Trans.*, 1889.
R.	XVII.	Lyginodendron Oldhamium, Bowmanites (Volkmannia) Dawsoni, now Sphenophyllum Dawsoni. Calamites. 1890.
S.	XVIII.	Bowmanites (now Sphenophyllum) Dawsoni. Rachiopteris ramosa, possibly R. hirsuta var. ramosa.
T.		"On the structure of the woody Zone of an undescribed form of Calamite." *Memoirs of the Manchester Literary and Philosophical Society*, 3rd Series, Vol. IV., Session 1868-9.
V.		"On a new form of Calamitean Strobilus." *Memoirs of the Manchester Literary and Philosophical Society*, 3rd Series, Vol. IV., Session 1869-70.
W		"On some Anomalous Oolitic and Palæozoic forms of vegetation." Royal Institution of Great Britain, Weekly Evening Meeting, Feb. 16, 1883.
X.		"On the relations of Calamites to Calamodendron," with description of an intermediate form. *Memoirs of the Manchester Literary and Philosophical Society*, 3rd Series, Vol. X,, 1886-7.
Y.		A Monograph on "the Morphology and Histology of Stigmaria ficoides." *Palæontographical Society*, Volume for 1886.
Z.		"On the Structure and Affinities of some Exogenous stems from the Coal measures." *Monthly Microscopical Journal*, Aug. 1, 1869.
AA.		"On the Organisation of Volkmannia (now Sphenophyllum Dawsoni).
BB.	XIX.	Lepidodendron Harcourtii *Brongniart*, Halonia, Ulodendron, Lepidophloios, Lepidostrobi, Lepidodendron Spenceri. *Phil. Trans.*, 1893.

INTRODUCTION.

The publication of Part I. of this Index seems to have supplied a felt want. Hence, I now proceed further with the experiment by issuing a second part. But experience has shown that in dealing with some of the larger families, *e.g.*, the *Lycopodiaceæ*, the scope of the publication must be enlarged, as well as some slighter alterations adopted. So far as the latter necessity is concerned, we have an example in the group of the *Sphenophyllæ*, respecting which much additional information has been obtained since the appearance of Part I. It has become necessary to alter the definition of the genus, so as not only to admit into it my *Asterophyllites Sphenophylloides* (*see* Part I., p. 12), but also the genus *Bowmanites Dawsoni*, as being the fructification of some of the true *Sphenophyllæ* (*see Nature*, No. 1,201, p. 11). It is obvious that we must now recognise an independent family of *Sphenophyllæ*, which, having points of affinity with more than one existing family, exhibits other distinctive features, which seem to separate it from all the recognised groups. An extension of my plan is still more necessary in dealing with the *Lycopodiaceæ*. In my *Memoirs* I have given provisional (not specific) names to several types of *Lepidodendroid* plants; but I have not always succeeded in defining so clearly as is desirable the respective characteristics of these types. What thus seems to be lacking will be supplied in this second part of the Index.

The recent discoveries in connection with *Sphenophyllum* make it necessary to regard the lower half of p. 12, the whole of p. 13, and the two upper lines of p. 14, as transferred to the present one, under the head of *Sphenophyllæ*. They need not be re-printed, but require to have added to them the memoranda relating to *Bowmanites Dawsoni*. M. Zeiller's observations (*see Nature*, No. 1201, p. 11), show that the fructification described by me under the above name is apparently that of a true *Sphenophyllum*; but connecting my discovery of the peculiar form of its primary tracheal strand, with the absolutely identical form of the same organ in the vegetative stem of a *Sphenophyllum* represented in *Memoirs* XVII., Pl. 15, fig. 19, we see that we have here a very distinct modification of the *Sphenophylloid* type. The robustness of its primary tracheal strand differs conspicuously from the homologous slender triangles alike of the types figured by M. Renault and myself; hence, we have obviously equally in the stem and the fruit-axis of my *Bowmanites Dawsoni*, what must be regarded as a distinct form of *Sphenophyllum*. This form most probably belongs to some one of the structureless specimens which have already received specific names; but since we cannot at present identify it with any one of them, I shall, for the present, recognise my stem and fruit by the name of *Sphenophyllum Dawsoni*. *Will.*

SPHENOPHYLLÆ.

SPHENOPHYLLUM DAWSONI. Will.

BOWMANITES DAWSONI. *Will.*

VOLKMANNIA DAWSONI. *Will.*

VEGETATIVE STEM.

Primary Tracheal Strand.

R.—p. 100, Pl. 15, Fig. 19a, C.N. 1898D.

Secondary (or exogenous) Xylem Strand.

R.—p. 100, Fig. 19b, C.N. 1898D.

CORTEX.

R.—p. 100, Fig. 19c.

FRUCTIFICATION.

AXIAL STRUCTURES OF THE STROBILUS.

PRIMARY TRACHEAL STRAND.

Transverse.

S.—p. 256, Fig. 1a, C.N. 1049.

Longitudinal.

S.—p. 256, Fig. 4a, C.N. 1050.

CORTEX.

Inner Transverse.

S.—p. 256, Fig. 1a′.

Outer Transverse.

S.—p. 256, Fig. 2b, C.N. 1040B.
——— Fig. 3b′b″, C.N. 1040B. Fig. 9b, 1049A.

Outer Longitudinal.

S.—p. 256, Fig. 4b, C.N. 1050.
——— Fig. 8b, C.N. 1058.

NODAL DISKS.

Transverse.

S.—p. 256, Fig. 7d, C.N. 1049C.
p. 257, Fig. 2d, C.N. 1049B.
p. 258, Fig. 9d, C.N. 1049A.

Vertical.

S.—p. 256, Fig. 4d, C.N. 1058. Fig. 5d, C.N. 1058.
——— Fig. 8d′, C.N. 1058.

PERIPHERAL BRACTS.

Transverse.

S.—p. 257, Fig. 10e′, C.N. 1045. Fig. 2e, C.N. 1049B.
——— Fig. 11, C.N. 1898B.

Longitudinal.

S.—p. 257, Fig. 4e, C.N. 1050. Fig. 7e, C.N. 1049C.
——— Fig. 8e, C.N. 1050. Fig. 10e″, C.N. 1051.

SPORANGIOPHORES.

Transverse Sections.

S.—p. 258, Fig. 2f, C.N. 1049B. Fig. 5f, C.N. 1050. Fig. 7f, C.N. 1049B.

p. 258, Fig. 8f, C.N. 1050. Fig. 10ff, C.N. 1051.

p. 259, Fig. 15, C.N. 1898H.

LONGITUDINAL.

S.—p. 258-9, Fig. 4f, C.N. 1050. Fig. 5f, C.N. 1050. Fig. 7f, C.N. 1049B. Fig. 8f, C.N. 1050. Fig. 16f, C.N. 1049B.

SPORANGIOPHORAL TRACHEÆ.

S.—p. 258, Fig. 9f, C.N. 1049A. Fig. 14f, C.N. 1049B.

p. 259, Fig. 15, C.N. 1898C.

p. 260, Fig. 16f″f‴, C.N. 1049B.

SPORANGIA.

S.—p. 259-260, Figs. 2g, 4g, 10g.

p. 260, Fig. 16, C.N. 149B.

SPORES.

S.—p. 260, Figs. 17-18, C.N. 1053.

In the index to the plates in Memoir XVIII., the references to the cabinet number of the specimens figured should be, Fig. 6, C.N. 1049C, Fig. 7, C.N. 1049B; Fig. 8, C.N. 1050; and Fig. 10, C.N. 1051.

LYCOPODIACEÆ.

*Lepidodendron, Sternberg; Lepidophloios, Sternberg; Lomatophloios, Corda; Sigillaria Brong.; Stigmaria, Brong.; Syringodendron, Sternb.; Diploxylon, Corda.**

In dealing with this extensive family, I have already observed that some additions to the plan followed in Part I. appear necessary. In my *Memoirs* I have adopted the plan of giving provisional names to several of the types of form that I have described, but it must be remembered that in adopting this plan it is not my intention that these names should be regarded as specific ones. They are only assigned

* When my *Memoir*, Part II., was published (1872), I was struggling, aided only by limited supplies of imperfect material, to grope my way through the conflicting conclusions of preceding authors. This was especially the case with the *Anabathra* of Witham and the *Diploxylon* of Corda. The former is but a *Lepidodendron*. Even in that *Memoir* I determined that both these genera "are unmistakeably *Lepidodendroid* in structure" (loc. cit., p. 208). I have not referred to all the contents of that *Memoir* in this Index, because most of the objects described in it are described in much fuller detail in later *Memoirs*.

to facilitate references to certain types of organisation, some of which may ultimately prove to have a specific value, if we ever succeed in identifying their respective reproductive organs; but meanwhile many of those groups named most probably embrace several distinct though closely allied species. On the other hand, intermediate examples are already known, and more will doubtless be discovered, tending to unite these separate groups. This latter fact makes it difficult to define clearly the characteristics of each of these groups; hence my definitions, like my names, can only be regarded as provisional. Meanwhile I have endeavoured to indicate, in as concise a manner as I am able, the more prominent features of each group.

Type of Lepidodendron Selaginoides Sternberg? Lepidodendron vasculare, Binney; Sigillaria vascularis, Binney; Lepidodendron Selaginoides, Carruthers.

Sections of the youngest twigs, including the leaves, rather thick, ·45 of an inch in diameter. Primary central strand of long isomerous barred Tracheæ,* intermingled in its centre with numerous barred medullary cells. Innermost Cortex (liber or cambium?) of small celled parenchyma, containing numerous transversely intersected leaf-traces. Second cortical zone of larger and more uniform cells, with thicker walls. More externally, a zone of still larger cells, bounded peripherally by a prosenchymatous zone; very thin in the youngest twigs, but increasing to a considerable thickness as growth advances.

At a very early period an exogenous secondary xylem strand makes its appearance, commencing at some minute

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* For a good illustration of these Tracheæ see the longitudinal section, Cabinet No. 376A. I have recently discovered that in the most perfectly preserved examples the transverse bars of these tracheæ are connected by extremely delicate paralled vertical threads, like those described on p. 107, as characteristic of *L. Wunschianum*.

point at the periphery of the primary tracheal strand in the form of a very small number of barred tracheæ, to the periphery of which additional ones are steadily added, as well as on each side of the first formed ones, thus producing a small crescentic group, thickest radially in its centre. This crescent grows as it commenced, radially and at each slender horn, until it forms a perfect ring enclosing the primary tracheal cylinder. After this the growths are added to the entire periphery, thus producing an exogenous zone, what in my largest perfect specimen (C.N. 1922D), attains to a thickness of nearly ·2 of an inch; but in another larger fragment (C.N. 362AA) reaches ·55. The section 1922D, though the periphery of its prosenchymatous zone has disappeared along with the more superficial cortical tissues, has a mean diameter of four inches, what remains of its prosenchymatous zone alone having a thickness of 1·3.

AXIAL STRUCTURES.

MEDULLA.

B.—p. 199, Fig. 1a.

L.—p. 285, Fig. 1, C.N. 335. Fig. 3, C.N. 339. Fig. 5, C.N. 343. Fig. 6, C.N. 347.

Composition of Medullary Centres.

B.—p. 199, Fig. 3. Fig. 4. See C.N. 356 and 360.

L.—p. 285, Figs. 3 and 5, C.N. 339, 343 and 376A. See longitudinal section, 376A.

PRIMARY TRACHEAL STRAND.

The Etui Medullaire of Brongniart. This is the Primary Xylem of the Memoirs.

B.—p. 199 and 201, Figs. 3 and 4.

L.—p. 286, Fig. 3, C.N. 339. See also C.N. 367.

SECONDAY XYLEM STRAND.*

B.—p. 199, Fig. 1e.

L.—p. 286 *et seq.* Fig. 6h, C.N. 347. Fig. 7h, C.N. 363.

CRESCENTIC DEVELOPMENT.

L.—p. 286, *et seq.* Fig. 3, C.N. 339. Fig. 4, C.N. 343, Fig. 6, C.N. 347. Fig. 7, C.N. 363.

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*This is the Secondary or exogenous zone of the Xylem. I have introduced this new nomenclature for the first time into the Memoir, Part XIX. (BB) for the purpose of bringing our nomenclature into unison with that much used on the Continent.

MEDULLARY RAYS.

B.—p. 200. See C.N. 361.

I.—p. 337, Fig. 33m, C.M. 344. Fig. 34m and 35m, C.N. 350.
p. 338, Fig. 36m, C.M. 351. Fig. 37mm′, C.N. 350.

BARRED TRACHEIDS IN MEDULLARY RAYS.*

L.—p. 294, Figs. 21 and 22, C.N. 262A.

CORTEX. YOUNG STATE.

Innermost Cortex, or Liber. ?

I.—p. 337, Fig. 33g, C.N. 344.

L.—p. 285, Fig. 2b,b′,b″, C.N. 337.
p. 286, Fig. 4b. C.N. 343. Fig. 5b. See C.N. 344.
p. 288, Fig. 8b, C.N. 340. See also C.N. 338.

CORTEX.

Middle.

L.—p. 285, Fig. 2d, C.N. 337.

CORTEX.

Outer.

L.—p. 285, Fig. 1e, C.N. 335. Fig. 2e, C.N. 337. Fig. 4e, C.N. 343.

Prosenchymatous layer of outer Cortex.

L.—p. 285, Fig. 1f, C.N. 335. Fig. 2f, C.N. 337. Fig. 4ff′, C.N. 343.
For yet more advanced states see C.N. 363A and B, and 1922D.

LEAF-TRACES.†

I.—p. 338. Fig. 33m, C.N. 344. Fig. 34m, C.N. 350. Fig. 35m, C.N. 350. Fig. 36m, C.N. 351. Fig. 37m, C.N. 350.

L.—Fig. 3 c., C.N. 339. Fig. 4 c., C.N. 342. Fig. 6 c′, C.N. 347. Fig. 7 c., C.N, 363. Fig. 8 c′, C.N. 340.

LEAVES.

B.—p. 201. Fig. 1, l″. See C.N. 335, 336, and 337.

L.—p. 385. Fig. 1, g. C.N. 335.

BRANCHING.

Equal Dichotomy.

L.—p. 288. Fig. 8, C.N. 340.
See also C.N. 368 and 370.

Unequal Dichotomy.

C.N. 338. C.N. 1922D.‡

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*Some of these in the larger rays certainly belong to leaf-traces.

†See also 363B where two lateral branches are given off from opposite sides of the primary one. These are in all probability bundles going to Halonial tubercles, and indicate that the fructification was strobiloid as in other Lepidodendra, but this fructification has not yet been discovered.

‡An object thus named in some of my Memoirs, especially in L where it is seen, marked g′ in figures 1, 2 and 4, is now ascertained not to be a large leaf-trace, as formerly supposed, but an organ not uncommon in the leaves of the Lepidodendra and now named the adenoid. The history, and illustrations of its relations to the leaves, are given in Memoir XIX. (BB). See it also in the cabinet specimens 372, 373, 374.

Type of Lepidodendron brevifolum, Williamson, not of Ettinghausen. See Schimper, Paléontologie végétale, Vol. 2, p. 2.

Lepidophloios brevifolum, Will. C., p. 310.

Terminal twigs extremely slender and very abundant. The smallest about ·08 in diameter, including its leaves. Primary xylem strand consisting solely of a few barred tracheids, or with two or three medullary cells in its interior (C.N. 468 to 472). Diameter of the youngest strand, ·011 of an inch, but soon enlarging into a primary tracheal cylinder with a distinct central medullary cavity occupied by a medulla in C.N. 487.

Cortex in young twigs of two zones, an outer prosenchymatous one upon which the young leaves are planted, and an inner parenchyma. Twigs frequently dichotomise in a very young state (C.N. 467), when the xylem strand divides into two equal parts, each one soon developing into a distinct cylinder surrounding a medullary cavity. In more advanced growths, but yet comparatively early, an exogenous secondary xylem strand encloses the primary one. In my largest section this strand attains to a diameter of 1·3 of an inch, the central medulla being here ·5 broad. These larger branches are rare, and in what we possess all the cortical tissues internal to the prosenchymatous zones have disappeared. The medullary cells in such branches are in vertical rows, and their leaves approach those of *Lepidophloios*. In one specimen (C.N. 502), the secondary xylem strand is detaching a complete segment to become a strand of the *Halonial* type.

YOUNG TWIGS. AXIAL TISSUES.

MEDULLARY CAVITY.

C.—p. 284, Fig. 2. See C.N. 466, 467, and 469, and little, if any, parenchyma existing.

C.—p. 284, Fig. 1 and 3, C.N. 468.

C.—p. 285, Fig. 4. See C.N. 479.

C.—p. 286, Fig. 8, C.N. 917.

MEDULLA.

Vertical.

C.—p. 285, Fig. 5, C.N. 487.

PRIMARY TRACHEAL CYLINDER.

Transverse.

Young states seen in all the sections enumerated under the head Medullary Cavity.

Vertical.

C.—p. 285, Fig. 5, C.N. 487.

Dichotomy (Primary cylinder dividing).

C.—p. 291, Fig. 19. See C.N. 484.

——— Each half of the divided cylinder again become cylindrical See C.N. 467-486.

CORTEX.

Transverse.

C.—p. 284, Fig. 1, C.N. 468.

Vertical.

C.—p. 285, Fig. 6 and 7, C.N. 477.

LEAVES.

Transverse.

C.—p. 284, Fig. 1, C.N. 468.

Vertical.

C.N. 477.

MORE MATURED STEMS OR BRANCHES.

MEDULLA.

Transverse.

C.—p. 289, Fig. 15, C.N. 492. See also C.N. 489.

Longitudinal.

C.—p. 289, Fig. 14, C.N. 491. See C.N. 490.

PRIMARY TRACHEAL CYLINDER.

Transverse.

C.—p. 287. Fig. 9, C.N. 488.
p. 288, Fig. 11, C.N. 489.

Vertical. Radial.

C.—p. 288, Fig. 10, C.N. 498. See also 490 and 498.

SCONDARY XYLEM STRAND.

Transverse.

C.—p. 288, Fig. 11, C.N. 489. See also C.N. 501-2.

Vertical. Radial.

C.—p. 288, Fig. 10, C.N. 498. See also C.N. 490.

Tangential.

C.—p. 288, Fig. 12, C.N. 497. Fig. 13, C.N. 495. Fig. 22, C.N. 495.

MEDULLARY RAYS.

Tangential.

C.—p. 288, Fig. 13, C.N. 495. Fig. 22, C.N. 495.

Transverse.

C.—p. 288, Fig. 21, C.N. 503.

EXOGENOUS GROWTH: YOUNG TRACHEIDS.

C.—p. 292-3, Fig. 21, C.O. 503.

Dichotomy.

C.—p. 291, Fig. 20, C.N. 503.

Halonial form?

See 502.

LEAF TRACES.

Radial.

C.—p. 289, Fig. 10. See C.N. 498.

Tangential.

C.—p. 288, Fig. 12, C.N. 497.
——— Fig. 13, C.N. 495.

CORTEX.

Excepting its outermost Prosenchymatous and Parenchymatous Zones this structure is but imperfectly preserved in the more matured specimens of L. brevifolium.

C.—p. 290, Fig. 9i, C.N. 488. Fig. 11i, C.N. 489. Fig. 16, C.N. 504. Fig. 17, C.N. 505. See also C.N. 501.

LEAVES. Imperfectly preserved.

Transverse.

C.—p. 287, Fig. 9. C.N. 488.

Vertical.

C.—p. 290, Fig. 15a, C.N. 504.

Tangential.

C.—p. 291, Fig. 18, C.N. 506.

The Adenoid Organ seen in C.N. 480 and the Parichnos in 509.

External forms.

C.—p. 286, Figs. 31 and 32.

STROBILUS.

Several fine examples have been obtained in the Burntisland or Petticur deposit, and the stratum itself abounds in their microspores. Hence these reproductive organs may be fairly regarded as belonging to the only Lepidodendron also equally abundant.

Transverse.

C.—p. 294, Fig. 23, C.N. 520.

Vertical.

Microsporangial.

C.—p. 295, Fig. 24, C.N. 523. Fig. 25, C.N. 295.

B.B.—p. 26, Pl. 8, Fig. 51-52.

Macrosporangial.
C.—p. 296, Fig. 28, C.N. 524.
BB.—p. 26 Pl. 8, Fig. 51-52.
Macrospores.
C.—p. 296, Fig. 27x, 28x, C.N.524.

Type of Lepidodendron fuliginosum. Will; L. Harcourtii of the Memoirs prior to 1887.

Young branches (C.N. 379) less easily identified than older ones; approaching young forms of *L. Harcourtii*, from which they differ in the absence of the *Diploxyloid* leaf-trace characteristic of the latter plant. Young twigs apparently large; the smallest yet identified being ·6 of an inch in diameter, including its leaves. Medulla conspicuously developed even in young growths. The primary tracheal cylinder large and conspicuous, giving off great numbers of equally conspicuous, symmetrically arranged, leaf-traces. The most distinctive zone of the Cortex is the innermost one, the component cells of which, especially in the older branches, tend to arrange themselves in radiating rows. The cells of the more external layers of small size and very uniform aspect, causing the transverse sections to assume a remarkably sooty hue, which contrasts strongly with the brighter, more translucent, aspects of other allied forms. In many stems of advanced growth we find in the innermost Cortex, but separated from the periphery of the primary tracheal cylinder, a very rudimentary form of secondary xylem strand, and what exists is arranged in radial lines, symmetrical with those of the cells of the innermost Cortex; but these lines are very irregularly distributed, a group of them accumulated conspicuously at one part of the circle, whilst at other parts they are wholly wanting or only represented by one or two isolated radial lines. Vertical tangential sections through these lines of tracheæ shew that the perpendicular course is irregularly undulated instead of their being straight and parallel. Besides the leaf-traces, larger solid tracheal bundles are given off as segments from the primary tracheal cylinder. These appear to be Halonial fructigerous bundles.

AXIAL STRUCTURES.

MEDULLA. YOUNG STATE.

Transverse.

L.—Fig. 9a, C.N. 379.

Matured.

B.—p. 205, Fig 13a.
L.—p. 289, Fig. 9a, C.N. 379.
Fig. 10a, C.N. 384.

Vertical.

B.—p. 205, Fig. 14. See C.N. 1592 E. and 1643.

PRIMARY TRACHEAL CYLINDER.

Transverse.

Young State.

L.—p. 288, Fig. 9, C.N. 379.

Mature State.

L.—p, 289, Fig, 10, C.N. 384. See also 1648 and 9.

Vertical.

B.—p. 206, Fig. 14c. See 1643 and 4.
BB.—p. 18, Fig. 25, C.N. 396.

SECONDARY XYLEM STRAND.

Transverse.

L.—p. 289, Fig. 11, C.N. 387.
See also C.N. 1592A and 1648-9.

Vertical.

C.N. 1592B, C, D, and E, not yet figured.

CORTEX.

Innermost Zone. Transverse.

B.—p. 205, Fig. 13d.
L.—p. 289, Fig. 10b,b′,b″, C.N. 384. Fig. 11b,b′,b″, C.N. 384. See also 1592A.

Vertical.

B.—Fig. 14 (but not minutely described). See C.N. 1592 C and E.
BB.—p. 18, Fig. 25, C.N. 396.

MIDDLE ZONE.

Transverse.

B.—Fig. 13h.
L.—p. 289, Fig. 10 (upper half), C.N. 384. Fig. 9d, C.N. 379. See also C.N. 1643-4.

OUTER ZONE.

Transverse.

L.—p. 289, Fig. 9e, C.N. 379.

PROSENCHYMATOUS ZONE.

Transverse.

B.—p. 206, Fig. 13.i.

L.—Fig. 9f, C.N. 379.

LEAF-TRACES.

Transverse.

L.—p. 289, Fig. 10C, C.N. 384. See also C.N. 448k and l.

Longitudinal.

L.—p. 290, Fig. 10c″. See also C.N. 1643 and especially 1646.

BB.—p. 18, Fig. 25d, C.N. 396.

LEAVES.

Transverse.

L.—p. 289, Fig. 9g, C.N. 379.

Tangential.

See Sections 448 K and L, not yet described, but some of them shew Parichnos, Leaf-trace, and Adenoid Organ, described in Memoir XIX. (BB) in L. Harcourtii and Lomatophoios.

HALONIAL BRANCHES. Some not yet figured or fully described.

B.—p. 223-4.

Transverse.

C.N. 395. In this there is a hiatus at each extremity of the oval section of the primary vascular cylinder. From each hiatus a large solid vascular bundle has been given off to a Halonial tubercle; one tubercle is intersected at the periphery of the section.

Conversion of the segment of the primary vascular cylinder into a cylindrical bundle. Q.—p. 196.—Fig. 1-8. C.N. 1654-1656-1658-1659-1661.

Longitudinal.

B.—p. 224. C.N. 396. For figure and further description of this section see B.B. p. 18, Fig. 25l, C.N. 396.

Additional specimens in the cabinet further illustrating Halonial branch of L. fuliginosum are C.N. 397 to 401.

Type of Lepidodendron Wunschianum. Will.—The Laggan Bay Plant, Arran.

The most interesting of the *Lepidodendrons*, since we are familiar with its organisation from its youngest twigs to its oldest arborescent stems. Youngest twigs long and pensile, rarely found branched. Diameter of its axis internal to its circle of leaves about ·3 of an inch. In this state (C.N. 428) its primary tracheal strand is wholly vascular, devoid of any medulla, and about ·125 in diameter. In somewhat larger branches (C.N. 436) this primary strand is enlarged to ·16, but still without a medulla. In a yet larger example (C.N. 434) this bundle has expanded into a primary tracheal strand, in the centre of which is a medulla, ·1 in diameter, surrounded by a tracheal cylinder with a diameter of ·2. It is only when the branches have advanced greatly in size that any secondary tracheal strand makes its appearance; no trace of it exists in branches from which not only the leaves but the sub-foliar prosenchymatous zone has disappeared. I first find it beginning to develop in a branch (C.N. 450), the entire diameter of which must have exceeded six inches, whilst it attained its fullest expansion in stems that were eighteen or more inches in diameter. In these the secondary xylem strand attains a diameter of fully 2·7, in which examples the medulla has attained a width of ·5 and the primary tracheal cylinder of ·9.

The cortex consisted of several layers. The innermost one is composed of a small-celled parenchyma, which encloses numerous leaf-traces, as well as many small vacant spaces which are transverse sections of some vertically elongated cavities, conspicuous in longitudinal sections. Externally to this is a broad zone of very uniform parenchyma, composed of small cells passing externally into another zone of uniform tissue but composed of cells with thicker walls and of larger size. This is enclosed in the usual zone of prosenchyma, which, in the arborescent stems, has attained to a considerable thickness, having increased with age. We only know the leaves in their youngest state. They are imperfectly retained in the section C.N. 434, but they are fairly represented in the youngest twigs, C.N. 428 to 432. In 428 one leaf especially exhibits the leaf-trace, the two lobes of the parichnos and the adenoid organ. In addition to its ordinary tissues in the interior of the leaf, the leaf-trace is large and further surrounded by a number of large, but very short, almost spiral tracheæ, intermingled with the leaf-parenchyma. The various tracheæ of this plant, when well preserved, exhibit a feature long found, only in a very rare form, from Yorkshire *(L. mundum)*. But I have more recently discovered it in unusually well preserved sections of *Lepidodendron selaginoides* and of *L. Harcourtii.* The contiguous transverse bars of these tubes are connected together by innumerable very delicate parallel vertical threads of great tenuity.*

My cabinet contains a very well-marked Halonial branch of *L. Wunschianum*, in which the tracheal strands of the fructigerous tubercles are of the true Halonial type.

YOUNGEST TWIGS.

PRIMARY XYLEM STRAND.

K.—p. 434, Fig. 1a, C.N. 428.
Fig. 2, C.N. 428.

INNER CORTEX.

K. Feebly represented in Fig. 2, C.N. 428.

OUTER CORTEX.

K. Fig 1. Only fragmentary traces in C.N. 428 and 430, binding the leaves together.

LARGE TWIGS OR BRANCHES.

MEDULLA STILL WANTING.

Transverse.

C.N. 433.

Vertical.

C.N. 433, A and B.

* This is a valuable feature; being present in the youngest twig (See C.N. 431) on which there is no medulla, as well as in all the examples in which the medulla is developed, it becomes an important link in the chain of evidence demonstrating that all these differences of structure merely belong to the same plant in its several stages of growth and development. In some cases this feature is imperfectly preserved; but that this is due to accident is proved by the fact that we sometimes find the structure most distinct in one part of a strand, whilst it has wholly disappeared from another part of the same strand.

MEDULLA PRESENT.

Transverse.

K.—p. 495, Figs. 3 and 4* C.N. 434.

PRIMARY XYLEM CYLINDER.

K.—p. 495, Fig. 3 and 4* C.N. 434.

CORTEX—MIDDLE.

K.—p. 495, Fig. 3, C.N. 434.

MEDULLA.

Vertical.

See C.N. 435 and 448E and 448D not yet figured.

PROTOZYLEM.

See 435. The vertical threads of the Tracheids now very conspicuous.

STILL LARGER BRANCHES.

See C.N. 454 and 456 A. for transverse sections of the medulla, primary xylem, perfect innermost, and most of the outer middle cortex, and leaf-traces. The inner middle cortex has disappeared. For large leaf-traces see 448 A. For vertical sections of the same specimens, shewing identical tissues, see C.N. 448B. and C. and D. Another section, 448D., shews the origin and course of the leaf-traces. C.N. 448F. shews the elongated spaces producing the large openings seen in the innermost cortex of 456A., an anomalously large branch.

K.—p. 496, Fig. 5, C.N. 450.

Medullary area d. Exogenous secondary xylem i, outer middle cortex e, prosenchyma of cortex h. This section, though its medulla and its primary xylem cylinder have a greater diameter than is seen in much older stems, is nevertheless younger than others yet to be referred to, as is evidenced by the comparatively rudimentary state of its secondary xylem strand i.

MATURED ARBORESCENT STEMS.

These are fully 20 inches in diameter. The only tissues preserved in them external to the xylem strand are an external layer of prosenchyma two inches thick, which, when perfect, had apparently a much greater diameter.

PRIMARY XYLEM STRAND.

Medulla.

K.—p. 497, Fig. 6d. See C.N. 451 and 452 for the medullary spaces from which the tissues have disappeared.

PRIMARY TRACHAEL CYLINDER.

K.—p. 497, Fig. 6a and 6Aa. See C.N. 451-452.

SECONDARY XYLEM STRAND.

K.—p. 497, Fig. 6i and 6Ai. See C.N. 451-452.

HALONIAL BRANCH.

Transverse.

M.—p. 466, Fig. 21, C.N. 458.

PRIMARY TRACHAEL STRAND.

M.—p. 466, Fig. 21a, C.N. 458.

INNER CORTEX.

M.—p. 466, Fig. 21b, C.N.458.

OUTER MIDDLE CORTEX.

M.—p. 466, Fig. 21d, C.N. 458.

PROSENCHYMATOUS ZONE.

M.—p. 466, Fig. 21e, C.N. 428.

VASCULAR BUNDLES TO HALONIAL TUBERCLES.

M.—p. 467, Fig. 21fff, C.N. 465.
Fig. 22, C.N. 461. Fig. 23, C.N. 458.
Fig. 24, C.N. 464.

LEAF-TRACE. For comparison with size of Halonial bundles.

M.—p. 467, Fig. 25a, C.N. 465.

Longtitudinal.

See C.N. 1922A, shewing the vertical thread on the tracheæ.

C.N. STROBILI, PROBABLY OF L. WUNSCHIANUM.

Transverse.

C.N. 437-438.

Longtitudinal.

C.N. 457.

Type of Lepidodendron Harcourtii. Witham.

For many years I failed, in common with most of my contemporaries, to distinguish between this type and my *L. fuliginosum.* Hence all references to "*L. Harcourtii*" prior to the year 1887 must be regarded as applicable only to *L. fuliginosum.* This error was an easy one, because young branches of these two types closely resembled one another. But in fact, after Whitham and Brongniart described their original specimen, more than forty years elapsed before other fragments of the same type were discovered; latterly, however, we have been much more fortunate and the identification of each of the above two types has become easy. I now possess beautiful examples of both very young branches of *L. Harcourtii* invested by their leaves, as well as one of larger dimensions and more advanced growth than Harcourt's classic fragment.

In the youngest growths which I possess we have what appear to be sections of Halonial tubercles (C.N. 1596

C & E); we have the primary xylem strand composed of a cluster of barred tracheæ, but in the centre of which there may possibly be a few medullary cells; in my smallest ordinary twig (C.N. 1596 G) we already find a minute but well-defined medulla. The tracheæ of the primary cylinder, even in these young states, show the delicate vertical threads connecting the transverse bars already mentioned as occurring in the tracheæ of *L. Wunschianum.* In all these very young twigs there is but little differentiation of the zones of the cortex; in rather older ones we find an innermost cortex composed of delicate thin-walled parenchyma (C.N. 380a-381). The inner portion of the middle cortex has entirely disappeared. The thickness of the cell-walls of the outer-middle cortex increases as we approach the prosenchymatous zone. This zone commences as a segment only of a circle, but is soon converted by lateral extension into a perfect cylinder. In transverse sections of the more advanced stem this zone projects outwards in numerous acute vertically elongated prominences through which leaf-traces emerge to reach the leaves; the bases of these latter organs rest, as usual, upon a thin layer of cortical parenchyma. Varied sections of the leaves exhibit the characteristic organs of the *Lepidodendroid* type, having the leaf-trace, the double parichnos, and the adenoid organ.

What seem to be Halonial tubercles exist in these young growths, supplied with the large tracheal bundles devoid of medulla, so characteristic of Halonial and Ulodendroid appendages.

MEDULLA.

Transverse.

BB.—p. 3, Fig. 1a, C.N. 1596A.
p. 7, Fig. 3a, C.N. 380.
p. 7, Fig. 6a, C.N. 380a.

Longitudinal.

BB.— Fig. 26a C.N. 380b.

PRIMARY TRACHEAL CYLINDER.

Transverse.

BB.—p. 4, 5, Fig. 1b, C.N. 1596A.
p. 8, Fig. 3b, C.N. 380.
p. 5, Fig. 5, C.N. 381.
p. 5, Fig. 6, C.N. 380a.

Longitudinal.

BB.—p. 19-23, Fig. 29a, C.N. 1596D.

CORTEX.

INNER AND OUTER MIDDLE.

Transverse.

BB.—p. 7, Fig. 1d, C.N. 1596A.
p. 7, Fig. 2dd′, C.N. 1596D.

Longitudinal.

BB.—p. 7, Fig. 9d, C.N. 380f.
p. 7, Fig. 9A.d, C.N. 380d.
p. 19, Fig. 29d., C.N. 1596D.

PROSENCHYMATOUS ZONE.

Transverse.

BB.—p. 6, Fig. 1, e C.N. 1596A.
p. 9, Fig. 3, e′, e′, C.N. 380.
p. 7, Fig. 4, C.N. 1596A.
p. 7, Fig. 2e, C.N. 1596A.
p. 19, Fig. 26e, C.N. 380b.

Longitudinal.

BB.—p. 8, 9, Fig. 7xx′, C.N. 380.*
p. 7, Fig. 9, C.N. 380f.
p. 7, Fig. 9Ae, C.N. 380l.
p. 7, Fig. 10e, C.N. 380e.
Fig. 29e, C.N. 1596D.

OUTER CORTEX.

Transverse.

BB.—p. 7, Fig. 1f, C.N. 1596A.*
p. 7, Fig. 2f, C.N. 1596A.
p. 9, Fig. 3f. C.N. 380.
p. 19, Fig. 26f, C.N. 380b.

Longitudinal.

BB.—p. 7, Fig. 9, C.N. 380f.
p. 7, Fig. 9Af, C.N. 380l.
p. 7, Fig. 10f, C.N. 380e.
p. 19, Fig. 29f, C.N. 1596D.

LEAF-TRACES.

Transverse.

BB.—p. 11, Fig. 3c″, C.N. 380.
p. 9, Fig. 7f, C.N. 380*.
p. 10, Fig. 8, C.N. 1596.
p. 10, Fig. 10c, C.N. 380e.
p. 10, Fig. 12, C.N. 1596A.
p. 11, Fig. 13c′, C.N. 380k.

Longitudinal.

BB.—p. 10, Fig. 9c, C.N. 380f.
p. 10, Fig. 11ab, C.N. 380e.
p. 12, Fig. 19c, C.N. 380m.

LEAVES.—PARICHNOS AND ADENOIDS.

Transverse.

BB.—p. 11, Fig. 14, C.N. 380k.
p. 12, Fig. 15, C.N. 380.*
p. 12, Fig. 16c,c″, C.N. 380b.
p. 12, Fig. 17c′, C.N. 1596B.
p. 12, Fig. 18, C.N., 1596A.

HALONIAL ARRESTED FRUCTIGEROUS TWIGS.

PRIMARY CYLINDRICAL STRAND.

Transverse.

BB.—p.p. 19, Fig. 26B, l.′, C.l., C.N. 380b.
p. 17, Fig. 27l′, C.N. 380a.
p. 19, Fig. 28a, C.N. 380a.

Longtitudinal.

BB.—p. 19, Fig. 29c, b., C.N. 1596D.
p. 19, Fig. 29B,* C.N. 1596D

Type of Lepidodendron mundum. Will.

A new and very small form. My largest specimen, including its secondary exogenous xylem, but decorticated, is only ·2 in diameter, and my largest corticated, one without any secondary xylem strand, only ·3 of an inch, whilst my youngest one (C.N. 405A), including the cortex, is but ·033. The primary xylem strand commences as a solid vascular bundle of conspicuous tracheids, devoid of medulla; but this organ soon makes its appearance in a very minute form, and composed of extremely small cells; but both individual cells and medulla enlarge as the diameter of the twig increases. Even in its youngest state the cortical cells are remarkable for their robustness, and those of the medulla soon exhibit a similar aspect. In the early growths the primary tracheal cylinder is composed of a single ring of conspicuously large tracheids, surrounded by a limited number of very small peripheral ones; but in their most advanced state of growth two irregular rows of these more conspicuous vessels exist, also surrounded by smaller peripheral ones. This prominence of the small number of older tracheids constitutes one of the characteristic features of the type. Another such feature is presented by the individual tracheids as seen in longitudinal sections. The transversed lignified bars on their walls are connected by numerous delicate longitudinal threads, like those seen in the tracheids of *Lepidodendron Wunschianum* and *L. Harcourtii*, a distinguishing feature of this diminutive form which separates it from all others with which it might be confounded.

These twigs dichotomise at a very early stage of growth. I have but the one example figured in which a well-developed secondary xylem strand exists. No traces of leaves have been discovered on this plant.

YOUNGEST TWIGS.

PRIMARY TRACHEAL STRAND DEVOID OF MEDULLA.

Q.—p. 197, Figs. 7 and 8, C.N. 408.

CORTEX, OUTER.

Q.—Fig. 7, C.N. 408.

MORE ADVANCED GROWTH. PRIMARY TRACHEAL CYLINDER AND MEDULLA.

Transverse.

Q.—p. 197, Fig. 9, C.N. 406. See also 405A. Fig. 10, C.N. 416C. Fig. 11, C.N. 405. Fig. 12, C.N. 413.

Longitudinal.

Q.—p. 197, Fig. 13, C.N. 414. See also C.N. 415.

CORTEX.

Inner Transverse.

Q.—p. 197, Fig. 12, C.N. 413. See also C.N. 411.

Inner Longitudinal, C.N. 415.

Q.—p. 197, Fig. 13, C.N. 414.

Middle Transverse.
C.N. 405.
Middle Longitudinal.
C.N. 416.
Outer Transverse.
Q.—Fig. 7, C.N. 408.
Outer Longitudinal.
C.N. 414 and 415.

TRACHEIDS.
Longitudinal.
Q.—p. 197, Figs. 14A, and 14B, C.N. 414 and 415.

DICHOTOMY.
Transverse.
Q.—p. 198, Fig.14, C.N. 412. See also 416a.

EXOGENOUS SECONDARY XYLEM STRAND.
Q.—p. 198, Fig. 15, C.N. 416b.

Type of Lepidodendron Spenceri. Williamson.

A small and rare *Lepidodendroid* form, which exhibits so many peculiarities in its fructification that it may possibly be necessary sometime to make it the type of a new genus. I have only obtained a few specimens at a time, with long intervening intervals; hence the notices of the type scattered through several *Memoirs* have been imperfect and unsatisfactory. These notices will be found in *Memoirs* IX., X., XVI., and XIX. But the plant is most distinct, and though our knowledge of it is yet far from complete, what we do know being probably only its young state, it is now very coherent as far as it goes; hence I propose to extend this description of it to a greater length than has seemed needful in the case of the other types.

Its vegetative features are largely those of a young *Lepidodendron.* My specimens don't exceed a mean of 10 mm. in diameter, and the only one which has attained that size is a strobilus, including its sporangiophores and sporangia. None of my vegetative twigs exceed 4 millimetres; but they may have had a more external cortex than I have yet discovered, and their well-defined leaf-traces demonstrate that they possessed leaves in some form.

My early difficulties in the interpretation of my limited series of specimens arose from a fact I was then ignorant of. I now know that the structure of the axile primary tracheal strand is polymorphic. We appear to possess it in four conditions.

In type A the strand appears to consist wholly of barred tracheids; no trace of a central medulla being visible. This condition is seen in my cabinet specimens of vegetative twigs, 419b, No. 1,* 419b 2, 419b 3, and in the strobilus 624c and 627.

In type B the primary tracheal strand approaches closely to A, but in its centre there is a small number of thin-walled structures, which appear more like cells than vessels. See the twig 419 b4.

In type C we now find a perfectly distinct medulla, enclosed within a primary tracheal cylinder, composed of fully-matured and uniform barred tracheids. See twigs 624e, 624f, and a similar one in 619f, but from which latter the medulla has disappeared. The *Strobili* 624, 624a, 624f, 624g and 626 have similar medullæ.

The type D is the most interesting. The *periphery* of the primary tracheal cylinder consists, as in C, of fully-developed barred tracheids. The centre is occupied by very thin-walled vertically elongated cells of a strongly-marked pro-cambial aspect; but at the zone of contact of these two peripheral and central tissues we have an unmistakeable form of spiral Protozylem. These conditions appear in the twigs 419c and 419e, and in the *Strobilus* 424b.

Of the innermost cortex no trace remains. In most of the transverse sections a thin ring of the middle cortex surrounds the primary tracheal cylinder at a little distance from it. In some cases (C.N. 419f) we find this zone in

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* There are four stems in this slide severally marked 1, 2, 3 and 4.

absolute continuity with the more external Cortex. In longitudinal sections this zone pursues a somewhat undulating course, touching the periphery of the Tracheal cylinder at points where leaf-traces are originating (C.N. 419c), and at others uniting with the inner edge of the outer Cortex (C.N. 419e).

Sometimes the latter is an uniform parenchyma composed of rather thin-walled cells (C.N. 627), but in one longtitudinal section (C.N. 419e) this undulating inner zone is almost continuously united to the outer one by a mass of loosely aggregated cells, the entire structure being conspicuous for the coarseness of its tissues and the thickness of the cell-walls.

In transverse sections of the vegetative twigs, the periphery of the cortex has an undulating outline, with here and there small projecting points, that may possibly have been the bases of leaves. In such sections a characteristic feature of the plant is seen in this outer cortex, viz.: a circle of large dark-coloured areas alternating with lighter bands that separate them (See *Memoir* XVI., Fig 19, f″, f″). This feature scarcely reappears in the sections of the *Strobili*; Slightly so in C.N. 627.

I have long had a conviction that the remarkable Strobilus represented on Figs. 38 to 57, Plate 22 of my *Memoir* I., belonged to *L. Spenceri*, and the fortunate discovery by my friend Mr. Lomax of the specimen C.N. 642e, figured in *Memoir* B.B., Figs. 41 and 42, proves the correctness of my hypothesis.

The characteristics of the Strobilus are even more strongly individualised than are the vegetative twigs. As already shewn, the axial structures are virtually identical in the twigs and the fruits, with the single difference that the leaf-traces of the former supply the sporangiophores of the latter. Each sporangiophore (loc. cit. fig. 24) supports a single more or less spherical sporangium. The contents of each sporangium are most characteristic and unique. In its young state it appears to me that each sporangium has developed in its interior a number of cells which, collectively, seem to have been the representatives of an Archesporium. Each of these archesporial cells seems to have developed a cluster of apparently four daughter cells, which were sporangiferous. But only one of each of these clusters has come to maturity; the result being that in every instance we find a single spore surrounded by three, possibly more, sterile sister cells (see *Memoir* I., Fig. 57, C.N. 631, and *Memoir* B.B., Figs. 43-44, C.N. 624e). Each spore has a diameter of about 1·4 mm.

As already remarked, no traces of leaves or of branching specimens have yet been discovered. That leaves of some kind have existed is clear from the presence of numerous leaves-traces. Hence a suggestion made in my *Memoir* Q.—p. 199, apparently continues to be true.

VEGETATIVE ORGANS.

PRIMARY TRACHEAL CYLINDER.

Transverse Sections.

MEDULLA.

BB.—Fig. 41, C.N. 624e. Medulla absent from some sections, *e.g.*, C.N. 419b.

PRIMARY TRACHEAL CYLINDER.

Q.—p. 199, Fig. 19a, C.N. 419b. Medulla absent from this twig.

SPORANGIOPHORES.

I.—p. 340, Fig. 53c,c′,c″,c‴, C.N. 626.
I.—p. 340, Fig. 54c′,c″, C.N. 629.
I.—p. 340, Fig. 55c′,c″, C.N. 631.
I.—p. 340, Fig. 56c′,c″. See C.N. 624b.
K.—p. 501, Fig. 11e, C.N. 624.
BB.—p. 25, Fig. 50e,e′, C.N. 624b.

SPORANGIA.

I.—p. 341, Fig. 53d, C.N. 626.
I.—p. 341, Figs., 55d and 57d, C.N. 636.
I.—p. 341, Fig. 38.
K.—Fig. 11e, C.N. 624.
BB.—p. 25, Fig. 50f,f′,f″, C.N. 624b.

SPORES.

I.—pp. 341-3, Figs. 39a to 52a.
I.—Fig. 57g,g,g, C.N. 631.
BB.—p. 25, Figs. 43a, 44a, 45a, 47a, 48a,49, C.N. 624e.

LONGITUDINAL SECTIONS.

MEDULLA.

Q.—p. 199, Fig. 22a″, C.N. 419c.

PRIMARY TRACHEAL CYLINDER.

Q.—p. 199, Fig. 21a, C.N. 419c.
Q.—p. 199, Fig. 22aa‴, C.N. 419c.

LEAF-TRACES.

Q.—p. 199, Fig. 21a, C.N. 419c.
Q.—p. 199, Fig. 22a′, C.N. 419c.

STROBILUS.

PRIMARY XYLEM STRAND.

TRANSVERSE SECTIONS.

MEDULLA.

K.—p. 502, Figs. 11a and 12a, C.N. 624. See also 624e.

PRIMARY TRACHEAL CYLINDER

K.—p. 502, Figs. 11b, 12b, C.N. 624. See also 624e.

Longitudinal.

BB.—p. 25, Fig. 50b, C.N. 624b.

CORTEX OF TWIGS AND STROBILI.

Middle. Transverse Sections.

K.—p. 501, Figs. 11c and 12d, C.N. 624.
Q.—p. 199, Fig. 19e, C.N. 419b.

Outer.

I.—p. 347, Fig. 53b, C.N. 626.
K.—p. 501, Fig. 11d, C.N. 624.
Q.—p. 199, Fig. 19f,f′,f″,f‴. p. 199, Fig. 20, C.N. 419b.

LONGITUDINAL SECTIONS.

I.—p. 341, Fig. 54b, C.N. 629. Fig. 55b. Fig. 56b, C.N. 631.
BB.—p. 25, Fig. 50c, C.N. 624b.

Type of Lepidodendron intermedium. Will.

This very rare form, of which I have seen but two examples, has some features which ally it with *L. fuliginosum* and others in connection with *L. selaginoides.* It closely resembles the latter type in the intermingling of its innermost tracheæ of the primary xylem strand with the medullary cells; a very distinct feature, which, with this exception, I have only seen in *L. selaginoides*. On the other hand, it resembles *L. fuliginosum* in the small size, and the tortuous and irregular vertical arrangement of the tracheæ of its secondary xylem strand. This combination of the characteristics of two such extremely distinct types makes this plant a very interesting one. Its cortex approaches nearest to that of *L. selaginoides*. The diameter of the perfect twig is about ·5.

Transverse.

Q.—p. 198, Fig. 16, C.N. 417; see also 418.

Longitudinal.

Q.—p. 198, Fig. 17, C.N. 419.

Type of Lepidodendron parvulum. Will.

This type is only known in the form of slender twigs, which rarely exceed ·1 of an inch in diameter. Its principal characteristic occurs in its cortical tissues. Though so small, it has a distinct medulla, surrounded by the usual primary tracheal cylinder. The innermost cortex has disappeared from all my specimens; but a narrow cylinder of a middle cortex is always preserved, as is also the external one, with its periphery of leaves. The inner border of this outer cortex is characterised by forming a broad zone of circular loops or arches, the bases of the radiating pillars of which blend with the middle cortical ring. When perfect, each of these arched areas is filled with a distinct thin-walled parenchyma interposed between the middle and the outer layers of the bark. In one series of six sections of the same branching twig, we trace the usual dichotomy of the primary tracheal cylinder from its normal condition of a single ring through the various stages of development, first into two semicircular halves, up to the point where each half has developed into the perfect primary tracheal cylinder of a separate branch.

TRANSVERSE.

Medulla.

Q.—p. 200, Figs. 23, 24, and 25, C.N. 420 to 425.

Primary Tracheal Cylinder.

Q.—p. 200, Figs. 23, 24, C.N. 420-421.

Dichotomy.

Q.—p. 200, Fig. 25. C.N. 422 to 426.

Cortex.

Q.—p. 200, Fig. 23-24-25, C.N. 420, 421, 424.

Special Cells in the circular loops.

Q.—p. 200, Figs. 25e′ and 27, C.N. 425.

Type of Lepidodendron macrophyllum. Will.

A very rare form, of which not more than two specimens (possibly only one) has been discovered. The plant was described by Mr. Carruthers in January, 1872, at a meeting of the Royal Microscopic Society, and I figured it in a *Memoir* presented to the Royal Society in February of the the same year (C. Fig. 35). In its general features it approximates to the type of *L. Harcourtii*, but is distinguished by the structure of its leaf-traces, by its more robust character, and most of all by the large size of its leaf-sections. Mr. Carruthers described it as having no medulla—but this is a mistake. He also thought that its leaf-trace divided into two. But at that date we were all alike ignorant of the true structure of *Lepidodendroid* leaves. The apparently divided leaf-trace is really the leaf-trace, plus one of the lobes of the double *parichnos*. There is also an adenoid organ present.* Though this is obviously a distinct form of *Lepidodendron*, additional examples, affording further information respecting it, are much to be desired. Like the rest of its tissues its leaf-traces are remarkable for their robustness.

Medullary Cavity.

C.— . 298, Fig. 35, C.N. 377.

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* For these terms see the *Memoir* XIX, *i.e.* B.B.

Primary Tracheal Cylinder.

C.—p. 298, Fig. 35c, C.N. 377.

Outer Cortex, with leaf-traces and leaves, two of the latter with parichnos, and one apparently with an adenoid organ.

C.—p. 298, Fig. 35l, C.N. 377.

Type of Lepidophloios.

Lepidophloios, Sternberg; Lomatophloios, Gösppert.

A group of *Lepidodendroid* plants, which only differ from *Lepidodendron* in the shapes of the leaf-scars left by the deciduous leaves. The transverse diameters of these scars exceed the vertical ones; the reverse of what occurs in *Lepidodendron.*

LEPIDOPHLOIOS. ULODENDROID OR HALONIAL BRANCHES.

CORTICAL SURFACE.

p. Fig. 25A, C.N. 649B.

MEDULLA.

B.—Transverse. p. 209, Fig. 26A, C.N. 646.
BB.— ,, p. 20, Fig. 30a, C.N. 1955.
B.—Longitudinal. p. 209, Fig. 25a, C.N. 645.

PRIMARY TRACHEAL CYLINDER.

B.—Transverse. p. 209, Fig. 26c, C.N. 646.
BB.— ,, p. 20, Fig. 30b, C.N. 1955.
B.—Longitudinal. p. 209, Fig. 25c, C.N. 645.

CORTEX.

Middle.

B.—Transverse. p. 209, Fig. 24i, C.N. 646.
BB.— ,, p. 20, Fig. 30d, C.N. 1955.
B.—Longitudinal. p. 209, Fig. 27i, C.N. 645.

PROSENCHYMATOUS ZONE.

B.—Transverse. p. 210, Fig. 24k, C.N. 646.
Longitudinal. p. 210, Fig. 27k, C.N. 645.
BB.—Transverse. p. 20, Fig. 30e and 30A, C.N. 1955.
,, p. 21, Fig. 31e, C.N. 1995.
,, p. 21, Fig. 32e, C.N. 1956.
,, p. 22, Fig. 35e, C.N. 1946.

LEAVES.

B.—Longitudinal. p. 210, Fig. 27l,l', C.N. 645.
Transverse. p. 210, Fig. 24l,l', C.N. 647. Fig. 28, C.N. 647.
BB.— ,, p. 21, Fig. 30, C.N. 1955, Fig. 31, C.N. 1955.
,, p. 21, Fig. 32, C.N. 1956, Fig. 35, C.N. 1946.
BB.—Longitudinal. p. 21, Fig. 33, C.N. 1962, Fig. 34, C.N. 1963.

PARICHNOS.

BB.—Longitudinal. p. 21, Fig. 31gg, C.N. 1955, Fig. 32gg′, C.N. 1956
p. 21, Fig. 34g, C.N. 1963.
p. 22, Fig. 35gg, C.N. 1946.

BB.—Transverse. p. 22, Fig. 36g′ C.N. 1971
p. 22, Fig. 37gg, C.N. 1973.

LEAF-TRACE.

BB.—Transverse. p. 22, Fig. 36c, C.N. 1971, Fig. 37c, C.N. 1973.
Oblique. p. 21, Fig. 32c, C.N. 1956.
Longitudinal. p. 21, Fig. 31c, C.N. 1955, Fig. 33c, C.N. 1962.
,, p. 23, Fig. 35c, C.N. 1946, Fig. 38c. C.N. 1957.

ADENOID ORGAN.

Transverse. p. 22, Fig. 37h, C.N. 1973.
Longitudinal. p. 22, Fig. 33h, C.N. 1962.

FRUCTIGEROUS TUBERCLES.

Transverse. p. 23, Fig. 39, C.N. 1976.
,, p. 23, Fig. 40, C.N. 645D.

HALONIA & ULODENDRON.

It has long been obvious that these two terms represent objects that have no claim to generic rank. They are merely fructigerous branches of other genera.

For a detailed account of them, see *Memoir* XIX. (BB.) pp. 13, 14, 16, 17.

BB.—p. 16, Fig. 23. A Halonial branch of large dimensions, and in a very advanced stage of growth, but retaining the form which it assumed when a very young twig. Museum of the Owens College, Manchester.

BB.—p. 14, Fig. 24. A rather younger Halonial branch, with the cortex A preserved on the side A embedded in the sandstone matrix.

BB.—p. 14, Fig. 22. A young decorticated Halonial branch with the rows of tubercles C arranged in two opposite rows as in most of the Ulodendroid forms. C.N. 649A.

BB.—p. 14, Fig. 25A. Part of a branch of a Lepidophloios with the Ulodendroid fructigerous scars and tubercles arranged, like the similar tubercles of some Halonial forms in numerous vertical rows and in close mutual contact. C.N. 649B.

LEPIDOSTROBI.

Some of those figured in *Memoir* XIX. have already been referred to in connection with the types to which they appear to belong. But there are others which have not been identified with a corresponding degree of probability.

BB.—p. 16, Fig. 26A. Branch of a Lepidodendron, with a Lepidostrobus, b, still attached to its arrested lateral branch a′. The Museum of the Owens College.

BB.—p. 17, Fig. 27A. A Lepidostrobus attached to the extremity of a long primary twig. Museum of the Owens College.

BB.—p. 26, Figs. 53 and 54. Two Lepidostrobi in the British Museum.

BB.—p. 27, Figs. 55 and 56. Lepidostrobi in the collection of the British Museum.

HOMOSPOROUS.

BB.—p 27, Fig. 57. Lepidostrobus, C.N, 1614.

BB.—p. 27, Fig. 58. Homosporous (?) Lepidostrobus, C.N. 568.

BB.—p. 27, Fig. 59. Centre of Fig. 58. Further enlarged.

BB.—p. 27, Fig. 60. A bundle equivalent to a leaf-trace going to a sporangiophore of Fig. 58.

BB.—p. 27, Fig. 61. A partly tangential of the Strobilus 58, C.N. 574.

BB.—p. 28, Fig. 62. A restored vertical section of part of the Strobilus, Figs. 58 and 61.

BB.—p. 28, Fig. 63. Transverse section of a fragment of a Heterosporous Lepidostrobus, C.N. 587A.

BB.—p. 29, Fig. 64, An obliquely vertical section through a young Strobilus, C.N. 577.

THE SIGILLARIÆ.

Few types of fossil vegetation have been the subjects of so many changes, and occasioned so much discussion, as this one has done. At an early period the group appeared to be a well-defined one, though opinions varied widely as to the living plants they were supposed to represent. But unfortunately a specimen which fell into the hands of Brongniart became a veritable apple of discord. That author had already described the *Lepidodendron*, which, as mentioned on a previous page, had a medulla surrounded by a primary vascular cylinder, and which feature he regarded as typical of the *Lepidodendra*. In this newly-acquired fragment of a *Sigillaria* he found this primary tracheal cylinder surrounded by a secondary xylem strand. He somewhat hastily concluded that the first of these two conditions indicated a *Cryptogamic* plant and the second a *Phanerogam*. The conflicts of opinion to which these two conclusions led have been referred to on a previous page. The essential characteristics of the two groups now became one of internal organisation rather than of external contour. The end of all this has already been explained in the introduction to the *Lepidodendra*. The *Sigillariæ* are now reunited with the *Cryptogams*, and the essential distinction between them and the *Lepidodendra* again becomes one of external contour. The group, as now generally recognised is restricted to the genus *Rhytidolepis* of Sternberg and Brongniart's genus *Favularia*—the two representing the *Sigillariæ veræ* of that author, combined with the smaller division of the *Leiodermariæ* of Goldenberg.

From the magnitude of these trees, and their vast numbers, they must have been a conspicuous feature of the Carboniferous forests; yet it is a remarkable fact that extremely few fragments of them have hitherto been discovered in which their internal structure is preserved. Brongniart himself obtained and described one such fragment of *Sigillaria elegans*,* and at a later period MM. Renault and Grand Eury described another, *Sigillaria spinulosa*.†

In 1871 I obtained two fragments, one of the *Favularian* type and the other a true *Rhytidolepis*, both of which I figured and described in my *Memoir* II. They both proved to be portions of the cortex, only one of them extending inwardly beyond the prosenchymatous zone. The cortex of each corresponded exactly with that of the *Lepidodendra*, and in the *Favulariæ*, though not well preserved, we see distinct evidence of a medulla enclosed within a primary tracheal cylinder. In no single feature did these sections differ

*Archives du Muséum D'Hist. Nat. Vol. I. (1839) p. 406.

†Mémoirs présentés par divers savants a l'Academie des Sciences de l'Institut National de Francé, Tome XXII. No. 9.

from the *Lepidodendroid* type. Besides these I subsequently obtained three other fragments; one of *Sigillaria Reniformis*, of which a part of the primary tracheal cylinder is preserved (C.N. 651-652), along with a corresponding portion of its secondary xylem strand. A second one was of the *Rhytidolarian* type. The third was a *Sigillaria*, also belonging to Brongniart's *Sigillaræ veræ*. Tangential sections of this specimen shew clearly (C.N. 662) the transverse sections of the leaf-trace and its two vertically elongated parichnoid organs. The transverse section of the tracheal cylinder (C.N. 651) is important, because it is identical with a perfect cylinder in my cabinet detached from its cortical structure, and figured in *Memoir II.*, fig. 33. This cylinder consists of a primary tracheal cylinder enclosed within a secondary xylem strand one—the line of junction between the two being a crenulated one. This corresponds with what Brongniart found in his "*Sigillaria Elegans*" (really *S. Menardii*), as also did M. Renault in his *S. spinulosa*. In addition to these few examples Mr. Carruthers has long had in his possession a similar specimen in which the cortex and the two central tracheal structures are excellently preserved.

SIGILLARIA.—FAVULARIAN TYPE.

VERTICAL SECTION.

MEDULLA.

B.—p. 211, Figs. 29 and 31a, C.N., 684.

PRIMARY TRACHEAL CYLINDER.

B.—p. 211, Fig 31d., C.N. 684.

CORTICAL PROSENCHYMÆ.

B.—p. 211, Fig. 29dd,* Fig. 31g., Fig. 32k, C.N. 684.
Fig. 30k (*transverse*) C.N. 685.

OUTER CORTICAL PARENCHYMA AND LEAF-CUSHIONS.

B.—p. 211 (*longitudinal*), Fig. 32l, C.N. 684.
p. 211 (*transverse*), Fig. 30l, C.N. 685.

LEAF-CUSHIONS AND STROBILOID SCARS, TANGENTIAL.

B.—p. 211, Fig. 58, C.N. 678.—A cast.

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* The left-hand *d* should point a little further to the left. It now points to some Tracheids of the primary cylinder.

Type of Rhytidolepis.

CORTICAL LAYERS.

B.—p. 213, Fig. 39. Exterior surface of the Cortex.

PROSENCHYMATOUS ZONE.

B.—Transverse. p. 212, Figs. 35-36. See C.N. 659.
,, p. 213, Figs. 40 and 41. See C.N. 653.
Longitudinal. p. 213, Fig, 42i, k. C.N. 654.

OUTERMOST PARENCHYMA AND LEAF CUSHION.

B.—Transverse. p. 212, Figs. 35 and 36. See C.N. 659.
,, p. 213, Figs. 40 and 41. See C.N. 653.
Longitudinal. p. 213, Fig. 42l.

LEAF-TRACE.

B.—p. 214, Fig. 42m, C.N. 464.

For tangential sections of the cortical prosenchyma shewing tranverse ones of these leaf-traces with pairs of parichnoid organs, see 657 and 662.

Type of Sigillaria Reniformis, not yet figured or described.

C.N. 651, transverse section across two of the longitudinal cortical ribs shewing the inner prosenchyma and the outer parenchyma of the leaf-cushion. Within this is a transverse section of a portion of secondary xylem strand and the primary tracheal cylinder. These shew very clearly the undulating line of junction between the two, already referred to as being apparently a feature of at least some of the *Sigillariæ*. At the exterior of the secondary xylem there is a very distinct young zone of secondary exogenous growth. C.N. 652 shews two of the long cortical ribs with sections of leaf-traces—but no trace of adenoid organs. In the centre is a longitudinal section of the secondary xylem strand with vertical rows of medullary rays between the tracheæ.

STIGMARIA.

That *Stigmaria ficoides* is the root of various species of *Lepidodendron* and *Sigillaria* is now well known, though there appear to be forms of *Stigmaria* found in France which differ from the English type in the number of the sub-divisions of each root, beside some other obscure features respecting which the descriptions are vague and somewhat conflicting. The results of early observations are given in *Memoir* II. (B).

B,—p. 216, Fig. 53, a diagrammatic restoration of a root and rootlets. See also in C, fig. 37, a diagram illustrating the relations of the tissues of the stems to those of the *Stigmarian* roots and rootlets.

MEDULLA.

B.—Transverse. p. 216, Fig. 37a.
Longitudinal. p. 216, Fig. 43a.

XYLEM.—This is only a prolongation of the secondary xylem strand of the ærial stem; the primary tracheal cylinder not being prolonged into the roots.

B.—Tangential. p. 216, Fig. 48.
Longitudinal. p 216, Fig. 43e′, Fig. 44e.
Transverse. p. 217, Fig. 47e, 51e.

PRIMARY MEDULLARY RAYS.

B.—Tangential. p. 216. Fig. 48f′.
Transverse. p. 217, Fig. 47f′,
Vertical radial. p. 217, Fig. 43f′, Fig. 44f.
Secondary medullary rays. p. 217, Figs. 45f and 46.

CORTEX.

Innermost zone.

B.—Longitudinal. p. 218, Fig. 44g, 49g.

Prosenchymatous zone.

B.—Transverse. p. 218, Fig. 52k′, 51k.
Longitudinal. p. 218, Fig. 50.

OUTERMOST CORTEX.

B.—Transverse. p. 219, Fig. 51k. Fig. 52l.

ROOTLETS,

B.—Longitudinal, p. 219, Fig. 51oo′, 52oo′.
K.—Transverse. p. 292, Figs. 13 to 20.

ORIGIN OF ROOTLET BUNDLES.

B.—p. 216, Fig. 44n. Fig. 47n.

For more complete detailed descriptions of *Stigmaria* consult my *Monograph* Y. In it the references to the figures and descriptions of the various organs are so minutely given in the index to the plates that it is unnecessary to repeat them here.

The Rate of Explosions in Gases. By Harold B. Dixon, M.A., F.R.S., Professor of Chemistry in the Owens College.

(Received March 7th, 1893.)

§1. The rapid act of chemical change, which follows the kindling of an explosive mixture of gases, has of late years attracted the interest both of practical engineers and of theoretical chemists. To utilize for motive power the expansive force of ignited gases; to minimize the chance of disastrous conflagrations of fire-damp in coal mines; to follow the progress of chemical changes under the simplest conditions, are some among the problems presented in industry or science, demanding for their solution a knowledge of the phenomena of the explosion of gases.

Thirty-six years ago Bunsen described a method of measuring the rapidity of the flame in gas explosions. Passing a mixture of explosive gases through an orifice at the end of a tube and igniting the gases as they issued into the air, he determined the rate at which the gases must be driven through the tube to prevent the flame from passing back through the opening, and exploding inside the tube. By this method he found that the rate of propagation of the ignition of hydrogen and oxygen was 34 metres per second, while the rate of ignition of carbonic oxide, marsh gas, and coal gas with oxygen was less than 1 metre per second. Bunsen applied these results to the rate of explosion of gases in closed vessels, and his results were accepted without cavil for four-and-twenty years.

The idea of using the rate of explosion as a means of determining the course of a chemical reaction occurred to me in 1877, when investigating the influence of steam on the union of carbonic oxide and oxygen. If steam acts as a carrier of oxygen to the carbonic oxide by a series of alternate reductions and oxidations, an increase in the amount of steam present, beyond that required to initiate the reaction, should be accompanied by an increase in the rate of combination up to a certain limit. Attempts were therefore made to detect such an increase by measuring the velocity of the flame in a tube,* But while the difference in the rate of explosion between the nearly dry and the moist gases was well marked, the attempts to directly measure the rate of the explosion of the moist gases failed, owing to the great rapidity of the flame. In the spring of 1881 I attempted to measure the rate of explosion of carbonic oxide and oxygen with varying quantities of steam by photographing on a moving plate the flashes at the beginning and end of a closed tube 20 feet long. The two flashes appeared to be *simultaneous* to the eye, but no record of the rate was obtained, for the apparatus was broken to pieces by the violence of the explosion. Shortly after this attempt was made the first of the brilliant series of papers by MM. Berthelot and Vieille, and by MM. Mallard and Le Chatelier, was read before the French Academy of Sciences. The work of these French chemists has opened a new era in the theory of explosions.

In July, 1881, two papers appeared in the *Comptes Rendus*, one by M. Berthelot, the other by MM. Mallard and Le Chatelier. Both papers announced the discovery of the enormous velocity of explosion of gaseous mixtures. Other papers by the same authors quickly followed. M. Berthelot made the important discovery that the rate of explosion rapidly increased from the point of origin until it reached a maximum which remained constant, however long the column of gases might be. This maximum M. Berthelot stated to be independent of the pressure of the

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Phil. Trans., 1884, Pt. II., p. 635.

gases, of the material of the tube, and of its diameter above a small limit. The rate of explosion thus forms a new physico-chemical constant, having important theoretical and practical bearings. The name "l'onde explosive" was given by Berthelot to the flame when propagated through an explosive mixture of gases at the maximum velocity.

While Berthelot, associated with Vieille, was measuring the rate of the "explosion-wave" for various mixtures of gases, Mallard and Le Chatelier continued the study of the preliminary phenomena of explosion which precede the formation of the "wave." They showed by photographing on a revolving cylinder:—(1) that when a mixture such as nitric oxide and carbon bisulphide is ignited at the open end of a tube, the flame travels a certain distance (depending on the diameter and length of the tube) at a uniform velocity; (2) that at a certain point in the tube, vibrations are set up which alter the character of the flame, and that these vibrations become more intense, the flame swinging backwards and forwards, with oscillations of increasing amplitude; and (3) that the flame either goes out altogether, or that the rest of the gas detonates with extreme velocity. Again, when a mixture of gases was fired near the closed end of the tube they found the velocity of the flame regularly increased, as far as their instruments were able to record the rapidly increasing pace.

Mixtures of coal-gas with air, and of fire-damp with air, show phenomena of the first and second kind. Ignited at the open end of a tube these mixtures burn at a uniform rate for a certain distance, and then the flame begins to vibrate.

The vibrations acquire greater or less velocity according to the nature of the mixture and the conditions of the experiment; but the third régime of uniform maximum velocity is not set up. In narrow tubes the explosion soon dies out.

The phenomena studied by Mallard and Le Chatelier have been observed on a large scale in explosions in coal mines. It has been noticed that little damage was caused at the source of an explosion, and for a distance varying from 50 to 80 yards from the origin of the flame, while beyond that distance falls of roof, broken tubs, and blown-out stoppings have testified to the violence exerted by the explosion. Great as the destruction is which an explosion of fire-damp and air causes in a mine, it is fortunate that these mixtures do not *detonate*.

§2. In Berthelot's brilliant generalisation the actual velocities of explosion are compared with the mean velocity of translation of the gaseous products of combustion, supposing these products to contain all the heat that is developed in the reaction.

For instance, we know the total heat given out when hydrogen and oxygen combine. If this heat is contained in the steam produced, we can calculate what its temperature must be if we know its heat capacity. And if we know the temperature of the steam, we can calculate the mean velocity with which the molecules must be moving. Now Berthelot supposes that the heat is all contained in the steam produced. He assumes that the heat capacity of steam is the same as the sum of those of its constituents; and he supposes, moreover, that the steam is heated at constant pressure. Making these assumptions, he calculates out the theoretical mean velocity of the products of combustion of various mixtures, and finds a close accordance between these numbers and the explosion rates of the same mixtures. He concludes that the explosive wave is propagated by the impact of the products of combustion of one layer upon the unburnt gases in the next layer, and so on to the end of the tube at the rate of movement of the products of combustion themselves. If his theory is true, it accounts not only for the extreme rapidity of explosion of gaseous mixtures, and gives us the means of calculating the maximum velocity obtainable with any mixture of gases, but it also affords us information on the specific heats of gases at very high temperatures, and it explains the phenomena of detonation whether of gases or of solid or liquid explosives.

Table I. shows the explosion rates found by Berthelot, compared with the theoretical velocity of the products of combusion :—

TABLE I.

Berthelot's Experiments.

Gaseous Mixture.	Velocity in metres per second.	
	Theoretical.	Found.
H_2 + O Hydrogen and Oxygen.	2830	2810
H_2 + N_2O Hydrogen and nitrous oxide.	2250	2284
CO + O Carbonic oxide and oxygen.	1940	1090
CO + N_2O Carbonic oxide and nitrous oxide.	1897	1106
CH_4 + O_4 Marsh gas and oxygen.	2427	2287
C_2H_4 + O_6 Ethylene and oxygen.	2517	2210
C_2N_2 + O_4 Cyanogen and oxygen.	2490	2195
C_2H_2 + O_5 Acetylene and oxygen.	2660	2482
CO + H_2 + O_2 Carbonic oxide, hydrogen, and oxygen.	2236	2008

Two points in this table appeared to my mind as strong arguments that Berthelot might have here given the true theory of explosions: first, the close coincidence between the rates of explosion of hydrogen both with oxygen and nitrous oxide with the calculated mean velocities of the products of combustion; and secondly, the great discordance between the found and calculated rates for carbonic oxide with both oxygen and nitrous oxide. I had previously discovered that pure carbonic oxide cannot be exploded either with pure oxygen or pure nitrous oxide. The discordance found by Berthelot was what I should have expected from my own experiments.

TABLE II.

Combustible gases with oxygen and nitrogen.

Gases.	Velocity in metres per second.	
	Calculated.	Found.
$H_2 + O + N_2$	1935	2121
$H_2 + O + N_4$ ... ... (Air)	1820	1439
$CO + O + N_2$	1661	1000 ?
$CO + O + N_4$	1236	Detonation not propagated.
$CH_4 + O_4 + N_4$	2002	1858
$CH_4 + O_4 + N_8$	1744	1151
$CH_4 + O_4 + N_{15}$ ... ... (Air)	1450	Detonation not propagated.
$C_2N_2 + O_4 + N_2$	2334	2044
$C_2N_2 + O_4 + N_4$	2152	1203
$C_2N_2 + O_4 + N_8$	1920	Detonation not propagated.

When the explosive gases are mixed with an inert gas, nitrogen, which takes no part in the reaction, the same law holds good—except when the nitrogen is added in excess. Before the gases are diluted sufficiently to stop the explosion, there is found a marked falling-off in the velocity. The formula gives the theoretically highest rate the explosion can attain—a maximum reached in a few cases only, but approached in a large number.

A consideration of Berthelot's results, published in full in the 'Annales de Chimie,' led me to think it would be useful to repeat and extend these experiments. My objects were chiefly: (1) to determine as accurately as possible the rate of the explosion-wave for some well-known mixtures; (2) to measure the rate of the explosion wave in carbonic oxide and oxygen with different quantities of steam; and (3) to determine the influence of inert gases on the propagation of the wave.

§3. For a description of the apparatus employed, the mode of preparation of the gases and the chronograph arrangements, I must refer to my *Memoir* in the Philosophical Transactions for 1893.

Briefly, my apparatus differed from that of Berthelot's in the following particulars:—

a. The explosion tube was longer and wider.

b. The interrupters or 'bridges' were of silver foil, and no fulminate was used.

c. A longer space was allowed between the firing spark and the first 'bridge,' where the record of the rate was begun. This was found essential in several cases, especially when the mixture was fired under reduced pressure, or in presence of inert gases, in which cases the explosion does not reach its maximum rate for some feet.

d. The errors of the chronograph were largely eliminated by making blank experiments, and by repeating each experiment with the connexions of the chronograph *reversed*.

The results obtained with hydrogen and oxygen, with hydrogen and nitrous oxide, and with marsh gas and oxygen in exact proportions for complete combustion, were in close accordance with the mean results of Berthelot; for ethylene, acetylene, and cyanogen my numbers differed appreciably, but in no case differed by more than 7 per cent. from the rates observed by Berthelot:—

TABLE III.

Velocity of Explosion in Metres per Second.

		Berthelot.	Dixon.
Hydrogen and oxygen	$H_2 + O$	2810	2821
Hydrogen and nitrous oxide	$H_2 + N_2O$	2284	2305
Marsh gas and oxygen	$CH_4 + O_4$	2287	2322
Ethylene and oxygen	$C_2H_4 + O_6$	2210	2364
Acetylene and oxygen	$C_2H_2 + O_5$	2482	2391
Cyanogen and oxygen	$C_2N_2 + O_4$	2195	2321

The general agreement between these measurements leaves no room for doubt about the substantial accuracy of the results. The formula given by Berthelot does, therefore, express with a close degree of approximation the rates of explosion of many gaseous mixtures.

Experiments made on gases at different pressures showed slight variations in the rate of explosion; accurate measurements were therefore made on the rate of explosion of hydrogen and oxygen under pressures from 200 mm. to 1,500 mm. The following table gives the mean rates found :—

TABLE IV.

Pressure Experiments. $H_2 + O$.

Pressures.	200 mm	300 mm	500 mm	760 mm	1100 mm	1500 mm
Mean Rate...	2627	2705	2775	2821	2856	2872

These figures show that the rate of explosion increases rapidly with increase of pressure from 200 mm.; that the rate of increase diminishes, and that the velocity becomes nearly constant at two atmospheres pressure. Similar results were found in the explosion of other mixtures.

Berthelot's conclusion that the explosion-wave is independent of the initial pressure of the gases must, therefore, be modified. At low pressures the rate falls off, but above a certain *crucial pressure*, which, in the case of hydrogen and oxygen, seems to be about two atmospheres, the velocity is independent of the pressure.

§4. Berthelot's formula fails for the explosion of carbonic oxide with oxygen or nitrous oxide. This was to be expected if, in the detonation of carbonic oxide in a long tube, the oxidation is effected indirectly by means of steam, as it is in the ordinary combustion of the gas. Measurements of the rate of explosion of carbonic oxide and oxygen in a long tube showed that the rate increased as steam was added to the dry mixture, until a maximum velocity was attained when between 5 and 6 per cent of steam was present.

In the following table the *mean* results obtained with the dried and with the moistened gases are given :—

TABLE V.

Rate of Explosion of Carbonic Oxide and Oxygen saturated with Steam at Different Temperatures.

Conditio .	Per cent of Steam present.	Mean rate in Metres per Second.
Well dried	—	1264
Dried	—	1305
Saturated at 10° C...	1·2	1676
,, 20° ...	2·3	1703
,, 28° ...	3·7	1713
,, 35° ...	5·6	1738
,, 45° ...	9·5	1693
,, 55° ...	15·6	1666
,, 65° ...	24·9	1526
,, 75° ...	38·4	1266

§5. When electrolytic gas was mixed with an excess of either hydrogen or oxygen the rate of explosion was found to be altered; the addition of hydrogen increasing the velocity, the addition of oxygen diminishing it. The addition of an inert gas nitrogen, incapable of taking part in the chemical change, produced the same effect as the addition of oxygen—one of the reacting substances—only the retarding effect of nitrogen was less marked than that of an equal volume of oxygen. The retardation of the explosion-wave caused by the addition of an inert gas to electrolytic gas evidently, therefore, depends upon the volume and the density of the gas added. In the following table the retarding effect of oxygen on the explosion of electrolytic gas, is compared with that of nitrogen:—

TABLE VI.

Rate of Explosion of Electrolytic Gas with Excess of Oxygen and Nitrogen.

Volume of oxygen added to H_2+O	O_1	O_3	O_5	O_7
Rate	2328	1927	1707	1281
Volume of nitrogen added to H_2+O	N_1	N_3	N_5	N_7
Rate	2426	2055	1822	—

I think it a fair inference from these facts to conclude, when the addition of a gas to an explosive mixture retards the rate of explosion by an amount which depends upon its volume and density, that such added gas is inert as far as the propagation of the wave is concerned, and that any change which it may undergo takes place after the wave-front has passed by—in other words, is a *secondary* change.

This principle has been applied to determine whether, in the combustion of gaseous carbon, the oxidation to carbonic acid is effected in one or two stages—an important question, on which there is little experimental evidence. If, for instance, in the combustion of a hydrocarbon, or of cyanogen, the carbon is first burnt to carbonic oxide, which subsequently is burnt to carbonic acid, the rate of the explosion-wave should correspond with the carbonic oxide reaction, in this case the primary reaction; whereas, if the carbon of these gases burns to carbonic acid directly, in one stage, then the rate of the explosion-wave should correspond with the complete reaction.

Now, if we adopt Berthelot's formula as a working hypothesis, we can calculate the theoretical rates of explosion of marsh gas, ethylene, or cyanogen: (1) on the supposition that the carbon burns directly to CO_2, and (2) on the supposition that the carbon burns first to CO, and the further oxidation is a subsequent or secondary reaction. On the first supposition, if 100 represents the rate of explosion of these three gases burning to carbonic oxide, the addition of the oxygen required to burn the gases to carbonic acid should *increase* the rate of explosion:—

	Marsh Gas.	Ethylene.	Cyanogen.
Calculated rate of explosion when burnt to CO^2	104	103	107

Whereas if these gases always burn first to carbonic oxide, and the extra oxygen is inert in propagating the explosion-wave, then the addition of this inert oxygen would diminish the rate of explosion:—

	Marsh Gas.	Ethylene.	Cyanogen.
Calculated rate of explosion when burnt to CO with inert oxygen present ...	92	88	87

The experiments show that if 100 be taken as the rate of explosion when the oxygen is only sufficient to burn the carbon to carbonic oxide, the following are the rates found when oxygen is added sufficient to burn the carbon to carbonic acid:—

	Marsh Gas.	Ethylene.	Cyanogen.
Rates found	94	92	84

The results are, therefore, in favour of the view that in the explosion of these gases, the carbon is first burnt to carbonic oxide.

But it might be objected that the increase in rate found on diminishing the oxygen is due, as in the case of electrolytic gas with excess of hydrogen, to the lower density of the mixture. Taking the most favourable case—that of marsh gas—the density of the mixture is lowered 4 per cent by diminishing the oxygen from O_4 to O_3. Now, if the rate varies inversely as the square root of the density this would only increase the rate 2 per cent. So that even if the heat of the chemical reaction remained the same in the two cases, the observed increase in rate could not be accounted for by the diminution in density. I need not point out that in the case of cyanogen the diminution of oxygen is accompanied by an *increase* in density.

But stronger evidence is obtained by comparing the explosion rate of these gases (1) when fired with oxygen sufficient to burn the carbon in them to carbonic acid, and (2) when nitrogen is substituted for the oxygen in excess of that required to burn the carbon to carbonic oxide. We have seen that oxygen added to electrolytic gas hinders the explosion more than nitrogen. In precisely the same way oxygen added to a mixture of equal volumes of cyanogen and oxygen hinders the explosion more than the same volume of nitrogen. The conclusion we must come to is that the oxygen added to the mixture expressed by the formula $C_2N_2+O_2$ is as inert (so far as the propagation of the explosion-wave is concerned) as oxygen added to the mixture expressed by the formula H_2+O. The same phenomena occur in the explosion of marsh gas, ethylene, and acetylene.

TABLE VII.

The Rate of Explosion of Cyanogen (1) *with Oxygen, and* (2) *with Oxygen and Nitrogen.*

1.	Mixture.	1 vol. cyanogen, 1 vol. oxygen $C_2N_2 + O_2$	with addition of 1 vol. oxygen. $C_2N_2 + 2O_2$
	Rate ...	2728	2321
2.	Mixture.	1 vol. cyanogen, 1 vol. oxygen $C_2N_2 + O_2$	with addition of 1 vol. nitrogen. $C_2N_2 + O_2 + N_2$
	Rate ...	2728	2398

TABLE VIII.

The Rate of Explosion of Marsh Gas (1) *with Oxygen and* (2) *with Oxygen and Nitrogen.*

1.	Mixtures.	2 vols. methane, 3 vols. oxygen. $CH_4 + O_3$	with addition of 1 vol. oxygen. $CH_4 + O_4$
	Rate ...	2470	2322
2.	Mixtures.	2 vols. methane, 3 vols. oxygen. $CH_4 + O_3$	with addition of 1 vol. nitrogen. $CH_4 + O_3 + N$
	Rate ...	2470	2349

Table IX.

The Rate of Explosion of Ethylene (1) *with Oxygen and* (2) *with Oxygen and Nitrogen.*

1.	Mixtures.	1 vol. ethylene. 2 vols. oxygen. $C_2H_4+2O_2$	with addition of 1 vol. oxygen. $C_2H_4+3O_2$
	Rates...	2581	2368
2.	Mixtures.	1 vol. ethylene. 2 vols. oxygen. $C_2H_4+2O_2$	with addition of 1 vol. nitrogen. $C_2H_4+2O_2+N_2$
	Rates...	2581	2413

Table X.

The Rate of Explosion of Acetylene (1) *with Oxygen and* (2) *with Oxygen and Nitrogen.*

1.	Mixtures.	2 vols. acetylene. 3 vols. oxygen. $C_2H_2+O_3$	with addition of 2 vols. oxygen. $C_2H_2+O_5$
	Rates...	2716	2391
2.	Mixtures.	2 vols. acetylene. 3 vols. oxygen. $C_2H_2+O_3$	with addition of 2 vols. nitrogen. $C_2H_2+O_3+N_2$
	Rates...	2716	2414

These experiments show that in all the cases examined, viz: the combustion of cyanogen, marsh gas, ethylene and acetylene—the substitution of nitrogen for the oxygen required to burn the carbon from carbonic oxide to carbonic acid *increases* the velocity of the explosion. *These facts seem only consistent with the view that the carbon burns directly to carbonic oxide, and the formation of carbonic acid is an after-occurrence.*

§6. The experiments described above, as well as others made with the same mixtures further diluted with nitrogen, permitted an extended comparison between the theoretical velocities calculated by Berthelot's formula (θ) and the actual rates (v). This comparison is made in the following tables for electrolytic gas, diluted with oxygen and with nitrogen; for cyanogen burning to carbonic oxide, and when this mixture is diluted with nitrogen; for marsh gas, ethylene and acetylene all burning to carbonic oxide and steam, and for the same gases diluted with nitrogen. In calculating θ, I made a correction for the gases being at the ordinary temperature (13° C.) before explosion and not at absolute zero; the theoretical velocities are, therefore rather higher than those given by Berthelot. This correction raises the theoretical velocity of explosion of electrolytic gas from 2831 metres per second (Berthelot) to 2900.

TABLE XI.

Electrolytic Gas with excess of Oxygen added.

Mixture.	2 vols. hydrogen. 1 vol. oxygen. H_2+O	with addition of 1 vol. oxygen. H_2+O+O	with addition of 3 vols. oxygen. H_2+O+O_3	with addition of 5 vols. oxygen. H_2+O+O_5
Theory, θ...	2900	2252	1730	1476
Found, v...	2821	2328	1927	1707

TABLE XII.

Electrolytic Gas with excess of Nitrogen added.

Mixture.	H_2+O	H_2+O+N	H_2+O+N_3	H_2+O+N_5
Theory, θ...	2900	2321	1814	1558
Found, v...	2821	2426	2055	1822

These measurements show that Berthelot's formula, which gives a calculated rate 3 per cent. too high for pure electrolytic gas, also gives a calculated rate which is found to be 16 and 17 per cent. *too low* for the same gas when largely diluted with oxygen and with nitrogen respectively.

Again, in the explosion of cyanogen to carbonic oxide with its own volume of oxygen, and also when the same mixture is diluted with nitrogen, the theoretical rate calculated by Berthelot's formula is far too low :—

TABLE XIII.

Cyanogen and Oxygen with excess of Nitrogen added.

Mixture.	1 vol. cyanogen. 1 vol. oxygen. $C_2N_2+O_2$	with addition of 1 vol. nitrogen. $C_2N_2+O_2+N_2$	with addition of 2 vols. nitrogen. $C_2N_2+O_2+2N_2$
Theory, θ ...	2361	2083	1877
Found, v ...	2728	2397	2166

When marsh gas and ethylene are exploded with oxygen sufficient to burn them to carbonic oxide and steam, the observed rates are higher than those given by the formula :—

TABLE XIV.

Marsh Gas and Oxygen with excess of Nitrogen added.

Mixture.	2 vols. methane. 3 vols. oxygen. } CH_4+O_3	with addition of 1 vol. nitrogen. CH_4+O_3+N	with addition of 3 vols. nitrogen. $CH_4+O_3+N_3$
Theory, θ ...	2387	2211	1958
Found, ν ...	2470	2349	2154

TABLE XV.

Ethylene and Oxygen with excess of Nitrogen added.

Mixture.	$C_2H_4+2O_2$	$C_2H_4+2O_2$ $+N_2$	$C_2H_4+2O_2$ $+2N_2$	$C_2H_4+2O_2$ $+2N_2$	$C_2H_4+2O_2$ $+6N_2$	$C_2H_4+2O_2$ $+8N_2$
Theory, θ	2487	2234	2050	1796	1624	1498
Found, ν	2581	2413	2211	2024	1878	1734

The divergence between the calculated and observed rates varies with the dilution from 4 per cent to 16 per cent.

TABLE XVI.

Acetylene and Oxygen with excess of Nitrogen added.

Mixture.	2 vols. acetylene 3 vols. oxygen. } $C_2H_2+O_3$	$C_2H_2+O_3$ $+N_2$	$C_2H_2+O_3$ $+3N_2$	$C_2H_2+O_3$ $+4N_2$	$C_2H_2+O_3$ $+5N_2$	$C_2H_2+O_3$ $+6N_2$
θ.	2749	2397	1983	1848	1739	1650
ν.	2716	2414	2209	2116	2019	1908

Here, as in the case of electrolytic gas, the rate for the pure mixture is in close agreement with the calculated velocity. Taken by itself, this experiment (not tried by Berthelot) would have offered strong confirmation of the correctness of the theory. But as successive additions of nitrogen are made to the mixture, the calculated velocities fall *below* the observed rates, until with a large excess of nitrogen, the calculated rate is 16 per cent too low.

The gradual divergence between the observed and the calculated rates of explosion for different gaseous mixtures, as successive quantities of nitrogen were added to the pure explosive gas, led me to try the effect of diluting electrolytic gas with hydrogen. According to Berthelot's formula a slight increase in the rate should occur; actually a very marked increase in the rate was observed.

TABLE XVII.

Rate of Explosion of Electrolytic Gas with excess of Hydrogen added.

Mixture.	2 vols. hydrogen. 1 vol. oxygen. H_2+O	with addition of 2 vols. hydrogen. H_2+O+H_2	with addition of 4 vols. hydrogen. H_2+O+H_4	with addition of 6 vols. hydrogen. H_2+O+H_6
Theory, θ...	2900	3055	3061	3028
Found, v...	2821	3268	3527	3532

§7. If it is true, as Berthelot insists, that the formula gives a *maximum* velocity, which may be reached, but not surpassed, by the explosion wave, it is obvious that either the experiments or the formula is at fault.

Since the amount and regularity of the divergence between the found and calculated rates precluded the idea of experimental error being its sole cause, I was driven to conclude either that the hypothesis was incorrect, or that the formula used failed to express the hypothesis with exactness.

Let us examine the mode in which Berthelot calculates the theoretical velocity, *i.e.*, the mean rate of translation of the products of combustion at the temperature of the explosion. In Clausius' formula

$$v = 29{\cdot}354\sqrt{\frac{T}{d}}$$

M. Berthelot calculates the absolute temperature of the explosion by dividing the quantity of heat developed in the complete reaction by the specific heat of the products of combustion *taken at constant pressure*. He argues that each layer of gas, in transmitting the explosion, is heated under constant pressure. I cannot follow his reasoning.

"The combustion," he says, "in propagating itself from layer to layer, is preceded by the compression of the gaseous layer which it is about to transform. . . . The combustion of each layer produces both heat and at the same time the work necessary to compress the following layer—that is to say, the layer loses on this score just as much heat as it gained by its own compression. The whole proceeds, as far as the elevation of temperature is concerned, precisely as if we had operated under constant pressure." On the facts of the case there is no dispute. The gas is exploded in a closed vessel. Each layer is compressed before being fired; after firing it compresses the layer beyond it. Now, as regards this preliminary compression, each layer, in turn, expends the same energy as was previously communicated to it, and therefore, it does no work of its own. But a gas heated under conditions where it does no work is raised to the same temperature as it would be had its volume remained constant. M. Berthelot admits that it would appear at first sight as if the gases were heated at constant volume; he adds that the concordance of the calculated with the observed numbers supports his explanation of the phenomena.

Again, the fact that each layer is fired by compression involves the preliminary heating of that layer, and this heating must be added to the heat developed by its burning. The temperature of the burning layer must, therefore, be greater than that obtained by dividing the heat developed in the chemical change by the specific heat of the products of combustion.

When a sound wave alone is transmitted through a gas its velocity shows that each layer of gas forming the wave-front is heated by compression, and there seems no reason why this should not happen when the compression is accompanied by a chemical change.

To what extent is each layer heated before combustion? MM. Mallard and Le Chatelier* state that the explosion-wave will be propagated when each layer is brought by compression to its own temperature of inflammation. For hydrogen and oxygen, they find this temperature to be about 550°C., and calculate that a pressure of 30 atmospheres must be exerted upon the gas to raise it to this point. This temperature may be regarded as the *lowest limit* of the preliminary heating of each layer before combustion.

If we regard the transmission of the explosion to be due to the collisions of the molecules, and assume that molecules which are chemically inactive towards each other act as elastic bodies when they come into collision, and that molecules which combine chemically lose energy of translation and gain energy of vibration, then it must happen that unburnt molecules come into collision with burnt molecules and take up their energy in the form of motion. For instance, in the explosion of hydrogen and

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* *Recherches sur la Combustion des Mélanges Gazeux Explosifs*, p 88—91

chlorine the energy of the hydrochloric acid formed will be communicated by collision to molecules of hydrogen and chlorine ; these *heated* molecules, moving forwards, will meet *unheated* molecules moving backwards, when combination will occur between those of opposite kind. Heated hydrogen will thus combine with cool chlorine, and heated chlorine with cool hydrogen. If we assume that an exceedingly thin layer of gas may be heated *nearly* to the temperature of the neighbouring layer by exchange of energies on impact of the molecules, we may say that, on the average, the heat of combustion of each molecule of hydrochloric acid formed is communicated to a molecule of hydrogen or chlorine which *shares it* with a molecule of the opposite kind ; each molecule formed in turn will therefore have a temperature corresponding to the heat of chemical combination *plus* half the heat of a molecule previously formed. According to this view the temperature reached by each successive layer would increase until it was *double* that due to the chemical change alone. The temperature of the explosion would then remain constant, and the wave would advance at a uniform rate as long as it met the same mixture of gases.

If we accept the hypothesis that the explosion is propagated by molecular collisions, we have just seen that the movement of the products of combustion is communicated to the unburnt molecules in front. It will, therefore, follow that the rate of the advancing explosion will depend not only on the rate of translation of the products of combustion, but also on the rate of translation of the heated *but yet uncombined molecules.* If the burnt molecules communicate their rise of temperature without loss to the molecules in front, no difference in the mean rate of motion will be caused by this transference so long as the burnt and the unburnt gases are of the same average density. But if a change in density is produced by the combustion, the average velocity of the molecules in the burnt layer will differ from the average velocity of the molecules in the heated but yet unburnt layer, and this difference must be taken into account. Lastly, there is a correction to be applied for changes of density in the explosion which in part counteracts the foregoing correction. In the oxidation of hydrogen and of carbonic oxide there is a contraction from three volumes to two ; in the burning of cyanogen to carbonic oxide there is an expansion of two volumes to three.* If each layer of the reacting gases is heated at constant volume, a change in the number of molecules must affect the temperature reached.

§8. The criticisms, which I have ventured to make on Berthelot's method of calculating the mean rate of translation of the gaseous molecules concerned in the propagation of the explosion-wave, tend to show that the rate so calculated must be too small. But in attempting to apply corrections suggested by these criticisms, one is beset with difficulties. In discussing these difficulties in a lecture given before the British Association, at Manchester, in 1887, I remarked :—

"I think I have made it plain that it is not so simple a matter to calculate the rate of the explosion-wave ; but I also think that by following up this path of experiment we may be led to discover the true relation between the rate of explosion and the molecular rate. Perhaps the chief obstacle to our seeing this relation is the fact that few, if any, chemical changes are known which are sufficiently simple to show it."

I now advance as a working hypothesis the view that the explosion travels with the velocity of sound in a gas of the maximum temperature and of the density of the gases in the wave-front.

To obtain (approximately) the mean rate of translation

* M. Berthelot rightly takes this change into account in interpreting Bunsen's experiments on the temperature produced in explosions —*Ann. Chim. et Phys.*, v., xii., 302.

of the molecules concerned I have made the following assumptions :—

(1) That the explosion-wave is carried forward by the movements of molecules of density intermediate between that of the products of combustion and that of the unburnt gas ; (2) that the temperature of the gas propagating the wave is double that due to the chemical reaction alone ; (3) that the temperature is increased when the chemical volume of the products is larger, and is diminished when the chemical volume of the products is smaller, than that of the initial gases ; (4) that the gases are heated at constant volume, and their specific heats remain constant at high temperatures. On calculating out the mean rate of translation of the molecules on these assumptions one arrives at numbers greatly in excess of any of the observed rates of explosion ; but some of the observed rates agree with *the velocity of sound* in a gas of the temperature and density so calculated. For instance, when one volume of cyanogen is exploded with an equal volume of oxygen, two volumes of carbonic oxide are formed and one volume of nitrogen :—

$$C_2N_2 + O_2 = 2CO + N_2.$$

Taking the quantity of heat evolved as 126,100 calories, and the specific heat at constant volume of the products of combustion as $4{\cdot}8 \times 3 = 14{\cdot}4$, the temperature produced by the chemical change is 8,694°C. If the gases were initially at 13°, or 286° above absolute zero, the chemical reaction would raise the temperature to 8,980°. But since three molecules are formed where two previously existed, the temperature is further raised by the heat developed in compressing three volumes to two. This will raise the temperature to 10,595°. At *double* this temperature the mean rate of translation of a molecule of the mean density of the burnt and unburnt gases would be 3,892 metres per second. If the formula for the velocity of sound under ordinary conditions held good in the explosion, the velocity of the sound wave would be 2,670 metres per second—a rate which is about 2 per cent less than the observed velocity of the explosion-wave. Now, the theoretical velocity of sound is calculated on the assumption that the disturbance is very small; if the displacements are large the velocity of sound should be higher. Direct measurements of the velocity of sound waves of great intensity have confirmed this anticipation. Under ordinary conditions the rate of the sound wave is to the mean rate of the molecules as ·688 : 1. If we take the ratio in an explosion as ·7 : 1 the velocity of the sound wave agrees with the observed rate of explosion in this particular case.

We may now compare the rate of the sound wave so calculated with the velocity of explosion of cyanogen with oxygen (1) in presence of excess of oxygen; (2) in presence of excess of nitrogen; (3) of cyanogen with nitrous oxide alone, and (4) in presence of excess of nitrogen; and lastly, (5) of cyanogen with nitric oxide; taking the data furnished by Berthelot's experiments for the quantities of heat evolved.

TABLE XVIII.

The Rate of Explosion of Cyanogen mixtures compared with the calculated velocity of sound (Σ).

1. Cyanogen with Oxygen.

Mixture.	$C_2N_2+O_2$	$C_2N_2+2O_2$	$C_2N_2+3O_2$
Rate ...	2728	2321	2110
Σ	2725	2310	2066

2. Cyanogen with Oxygen and Nitrogen.

Mixture.	$C_2N_2+O_2$	$C_2N_2+O_2+N_2$	$C_2N_2+O_2+2N_2$
Rate ...	2728	2397	2163
Σ... ...	2725	2397	2166

3. Cyanogen with Nitrous Oxide and Nitrogen.

Mixture.	$C_2N_2+2N_2O$	$C_2N_2+2N_2O+N_2$	$C_2N_2+2N_2O+2N_2$
Rate ...	2454	2283	2098
Σ... ...	2416	2237	2093

4. Cyanogen with Nitric Oxide.

Mixture.	C_2N_2+2NO
Rate ...	2760
Σ... ...	2763

The formula that I have given was thus found to agree with all the cyanogen explosions. It is therefore, at all events, an empirical expression which can be applied to calculate the rates of explosion of cyanogen burning to carbonic oxide and nitrogen under a fairly wide range of conditions. It was accordingly a matter of considerable interest to apply the formula to the rates found when electrolytic gas was exploded by itself and when diluted with hydrogen, oxygen, and nitrogen. In the following table the rates for electrolytic gas with excess of hydrogen and of oxygen are compared with the numbers calculated from Berthelot's formula (θ), and with the sound wave (Σ) calculated as before.

TABLE XX.

The Rate of Explosion of Electrolytic Gas with excess of Hydrogen and with excess of Oxygen compared with calculated velocities.

Mixture.	H_8+O	H_6+O	H_4+O	H_2+O	H_2+O_2	H_2+O_4	H_2+O_6
Berthelot's θ... ...	3028	3061	3055	2900	2252	1730	1476
Rate of Explosion	3532	3527	3268	2821	2328	1927	1707
Σ... ...	3516	3571	3585	3416	2650	2024	1718

The Rate of Explosion of Electrolytic Gas with excess of Nitrogen compared with calculated velocities.

Mixture.	H_2+O	H_2+O+N	H_2+O+N_3	H_2+O+N_5
Berthelot's θ ...	2900	2321	1814	1558
Rate of Explosion	2821	2426	2055	1822
Σ	3416	2731	2122	1813

A glance at this table reveals the fact that the sound-wave calculated by my formula does not agree in velocity with the explosion wave of pure electrolytic gas; but as the electrolytic gas is more and more diluted, the observed and calculated velocities come nearer together, until, not far from the two limits of regular explosion, they are in close agreement. Conversely we have seen that Berthelot's formula gives the correct rate for pure electrolytic gas, but diverges more and more from the observed rates as the gas is diluted. Where Berthelot's "θ" fails to represent the facts, the "Σ" I have calculated does so; and *vice versâ.*

I advance the following hypothesis to account for this divergence. *At the high temperature of the explosion-wave the combination of hydrogen and oxygen is not complete; or, in other words, steam is partly dissociated under these conditions.* The temperature of the wave front is therefore less than that calculated. As more and more inert gases are added to electrolytic gas, the temperature of the explosion is lowered by the division of the heat between the diluent gases: more and more of the explosive gases are thus able to combine. As the gases are diluted, therefore, the temperature of the wave front comes nearer and nearer to that calculated.

Since steam is known to be partially dissociated under atmospheric pressure at the temperature of the oxy-hydrogen flame, it does not seem improbable that dissociation would also occur at the higher pressures and higher temperatures of the explosion-wave. The researches of MM. Berthelot and Vieille, and those of MM. Mallard and Le Chatelier, on the pressures registered in an explosion of gases, have led these investigators to the conclusion that the specific heat of steam rapidly rises with the temperature. The deficiency of "available" pressure, which Bunsen first observed in the explosion of gases, and attributed to incomplete combustion, they consider to be due to an increase of specific heat. Such an increase in the specific heat of steam with rise of temperature would explain the divergence between the observed and calculated rates of explosion of hydrogen with oxygen. And, conversely, it appears to me that the results of the French experimenters might be equally well explained by the temporary dissociation of steam in their explosions.

That the combustion of pure electrolytic gas is not *wholly* complete in the explosion-wave has been proved by collecting the residue and exploding it.* In the propagation of the wave the cooling due to expansion is so rapid that some molecules of hydrogen and oxygen, which are unburnt in the wave-front, have not time to combine before they are cooled below the temperature of combination. In a leaden tube, 9 mm. in diameter and 100 metres long, about 1 per cent of electrolytic gas was found uncombined after the explosion. That this incompleteness of combustion was not due to the cooling effect of the walls was shown by making comparative experiments in tubes 4 mm. and 19 mm. in diameter. Nearly the same percentage of unburnt residue was found in all the tubes, and also when the gases

* "Incompleteness of Combustion in Gaseous Explosions," by H. B. Dixon and H. W. Smith. *Manchester Memoirs* [IV.] 2 1888.

were detonated in an iron bomb 100 mm. in diameter. We have, therefore, positive evidence that in the explosion-wave the combustion of electrolytic gas is incomplete : it seems, therefore, not unreasonable to assume that in the wave-front—*i.e.*, at the highest temperature—a considerable proportion of hydrogen and oxygen is uncombined, and the propagation of the wave is retarded accordingly.

§9. Mixtures of oxygen with the hydro-carbons ethylene and acetylene will explode when largely diluted with nitrogen. It is found both with ethylene and acetylene that the rate of explosion exactly agrees with the calculated velocity of the sound-wave when the mixtures are largely diluted with nitrogen, but not when the gases are exploded without dilution :—

TABLE XXI.

Rate of Explosion of Ethylene and Oxygen with excess of Nitrogen compared with calculated velocities.

Mixture.	$C_2H_4+2O_2$	$C_2H_4+2O_2+4N_2$	$C_2H_4+2O_2+6N_2$	$C_2H_4+2O_2+8N_2$
Berthelot's θ.	2487	1796	1624	1498
Rate of Explosion ...	2581	2024	1878	1734
Σ	2856	2073	1873	1727

Rate of Explosion of Acetylene and Oxygen with excess of Nitrogen compared with calculated velocities.

Mixture.	$C_2H_2+O_3$	$C_2H_2+O_3+N_8$	$C_2H_2+O_3+N_{10}$	$C_2H_2+O_3+N_{12}$
Berthelot's θ	2749	1848	1739	1650
Rate of Explosion ...	2716	2116	2019	1908
Σ	3187	2144	2016	1910

§ 10. Lastly, I have determined the rate of explosion of hydrogen and chlorine in different proportions, and compared the rates found with the calculated velocities of sound. The explosions were made in a long glass tube.

The mean rate of explosion of dry electrolytic hydrogen and chlorine was found to be 1729 metres per second. About 1 per cent of the combustible gases were found uncombined after the explosion.

The heat of combination of hydrogen and chlorine was found by Favre and Silbermann to 23,780 calories; by J. Thomsen it was found to be 22,000 calories. Berthelot gives one determination 22,100 calories. The mean of these numbers is 22,630 calories. Taking Thomsen's number for the heat of combination, the mean rate of translation of the products of combustion according to Berthelot's formula (corrected to 13°C) is found to be 1,551 metres per second; taking the mean number 22,630 cals. for the heat of combination, Berthelot's formula gives 1,571 metres for the mean rate. The rate of explosion of hydrogen and chlorine under ordinary conditions is, therefore, considerably faster than the rate given by Berthelot's formula. The velocity of the sound-wave (Σ) calculated by my formula is 1,805 or 1,830, according as the lower or higher heat of combination is taken. The rate of the explosion thus falls appreciably below the calculated velocity of the sound-wave.

On diluting the electrolytic gas with hydrogen the rate of explosion was found to increase, and to approximate to the calculated velocity of the sound-wave. While the addition of diluent hydrogen to the electrolytic gas makes little difference in the calculated rates, the observed velocities of explosion increased appreciably. On the assumption that the heat of combination of hydrogen and chlorine is 22,630 calories, the calculated and observed velocities are as follows :—

TABLE XXII.

Rate of Explosion of Hydrogen and Chlorine with addition of Hydrogen.

Mixture.	H_2+Cl_2	H_4+Cl_2	H_6+Cl_2
Berthelot's θ... ...	1571	1581	1589
Rate of Explosion	1729	1849	1855
Σ	1830	1832	1832

These experiments show that in the explosion of hydrogen and chlorine as in the explosion of hydrogen and oxygen, in equivalent proportions, the rate falls below the calculated velocity of the sound-wave, but on diluting the gases the calculated and observed velocities come together. This divergence at the highest temperature may be explained either by the dissociation of the hydrochloric acid or by a rise in its specific heat. As I have shown, we have direct evidence of *some* dissociation. On the other hand the physical properties of hydrochloric acid more nearly resemble those of carbonic oxide and the elementary gases than those of steam or carbonic acid; we should expect, therefore, that the specific heat of hydrochloric acid should remain as constant as that of carbonic oxide at high temperatures.

I am aware that some of the assumptions made in calculating the temperature of the wave-front cannot be strictly accurate. For instance, the high velocities of the molecules in a heated layer cannot be transferred without loss to the molecules of the next layer, or otherwise sound would be propagated in a gas at the rate of the original disturbance. Again, I assume that the whole heat of chemical combination is developed in the wave-front, an assumption that requires the chemical change to be completed within exceedingly small limits of space and time in those cases where dissociation does not occur. It has been suggested that there is not a true wave motion in the explosion, but that the wave breaks and sends forward jets of heated gas which produce secondary waves coalescing and breaking in turn.

The tentative formula I have proposed must be regarded as nothing more than a working hypothesis.

In conclusion, I would say that these experiments have amply confirmed the truth of Berthelot's statement that the explosion-wave is a "specific constant" for every gaseous mixture; that it has been shown that the rate of explosion depends upon the primary reaction occurring, and that the determination of the rate may throw some light on what is now so obscure—the mode in which chemical changes are brought about; and, finally, that it does not seem impossible that a connexion between the rate of the molecules and the rate of the explosion may be worked out, which will give us some definite information on points of high interest in the theory of gases.

Ordinary Meeting, February 21st, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

In pursuance of a resolution of the Council, the meeting was opened at five o'clock instead of seven o'clock, the usual hour, as an experiment. There was a good attendance, and a conversation took place as to the desirableness of the meetings being occasionally held at the earlier hour, to suit the convenience of members residing at a distance or otherwise occupied in the evening. The general feeling appeared to be in favour of the new departure, and a suggestion that the meetings should be alternately held at five and seven o'clock seemed to meet with approval.

The thanks of the members were voted to the donors of the books upon the table.

Mr. J. WILSON, introduced by Professor SCHUSTER, read a paper "On the Comparison between Maxima and Minima of Temperature observed in different parts of Manchester during the period of frost, December 4th, 1892, to January 28th, 1893." A discussion ensued, during which the prevailing direction of the wind was mentioned as a probable factor in the problem.

A paper by Mr. B. LEAN, B.SC., and Professor H. B. DIXON, M.A., F.R.S., "On the Length of Flame produced in Explosions in Tubes," was read by the latter. A discussion ensued on the relation of the phenomena to coal-mine explosions.

Comparison of Observations of Temperature taken at two stations in Manchester from December 4th, 1892, to January 28th, 1893. By J. Wilson. Communicated by Arthur Schuster, Ph.D., F.R.S., F.R.A.S.

(Received March 7th, 1893.)

Since August, 1892, systematic meteorological observations have been taken at the Observatory in Whitworth Park, Manchester. These have been compared with similar readings taken at the Oldham Road (the "Manchester City") Observatory, and it has been thought that a short summary of the results of such a comparison would not be without interest to members of this Society.

The period chosen for a detailed comparison extends from December 4th, 1892, to January 28th 1893; this being selected as it contains the periods of lowest temperature of the winter 1892-3.

The Oldham Road Observatory is situated in an industrial area on the north side of the town, Whitworth Park being in a residential area on the south side. Both stations are about one mile distant from the centre of the city.

All the observations are taken at 9 a.m. The thermometers at both observatories have been verified at Kew, and they are exposed in Stevenson's screens, 4 ft. high, over grass.

The observations which have been tabulated are the following:—

I.—Maxima in the shade.
II.—Minima " "
III.—Means of I. and II.
IV.—Temp. at 9 a m. in the shade.

The following Tables explain themselves, the period to which the numbers apply is the 24 hours ending at 9 a.m. on the date given in the first column. The differences for the maxima have been formed by subtracting the Oldham Road from the Whitworth Park observations, while in the case of the minima the observations taken at the latter place are subtracted from those taken at the former.

(1) December 4th to 10th (inclusive).

W.P. = Whitworth Park ; O.R. = Oldham Road.

24 hours ending 9 a.m. on	SHADE. *Max.* *W.P.*	*O.R.*	*Diff.*	*Min.* *W.P.*	*O.R.*	*Diff.*	*Mean.* *W.P.*	*O.R.*	*Temp. at 9 a.m.* *W.P.*	*O.R.*
Sun. Dec. 4. ...	45·7	44·	1·7	30·	30·2	0·2	37·9	37·1	30·2	31·0
Mon. „ 5. ...	35·3	33·4	1·9	17·2	25·2	8·0	26·3	29·3	21·4	26·3
Tues. „ 6. ...	33·4	35·	—1·6	19·8	25·8	6·0	26·6	30·4	33·4	34·8
Wed. „ 7. ...	39·8	39·8	...	29·4	30·3	0·9	34·6	35·1	36·7	35·2
Thur. „ 8. ...	40·2	38·8	1·4	22·5	26·6	4·1	31·4	32·7	27·3	30·5
Fri. „ 9. ...	37·2	36·6	0·6	27·1	30·0	2·9	32·2	33·3	36·3	36·0
Sat. „ 10. ...	37·8	36·4	1·4	20·7	25·4	4·7	29·3	30·9	23·4	27·2
Sums..............	269·4	264·	5·4	166·7	193·5	26·8	218·3	228·8	208·7	221·0
Mean	38·5	37·7	0·8	23·8	27·6	3·8	31·2	32·7	29·8	31·6

(2) December 11th to 17th (inclusive).

24 hours ending 9 a.m. on	*Max.* *W.P.*	*O.R.*	*Diff.*	*Min.* *W.P.*	*O.R.*	*Diff.*	*Mean.* *W.P.*	*O.R.*	*Temp. at 9 a.m.* *W.P.*	*O.R.*
Sun. Dec. 11....	39·4	40·1	—0·7	20·3	26·8	6·5	29·9	33·5	36·3	38·2
Mon. „ 12....	43·8	43·8	...	35·6	38·4	2·8	39·7	41·1	40·8	41·8
Tues. „ 13....	45·2	42·6	2·6	31·4	35·4	4·0	38·3	39·0	35·6	35·4
Wed. „ 14....	43·9	43·5	0·4	31·0	35·2	4·2	37·5	39·4	43·9	43·5
Thur. „ 15....	50·8	50·8	...	41·7	43·3	1·6	46·2	47·1	44·6	45·9
Fri. „ 16....	52·6	51 9	0·7	33·3	38·8	5·5	42·9	45·4	36·1	40·5
Sat. „ 17....	49·8	49·4	0·4	35·5	40·3	4·8	42·7	44·7	49·1	49·4
Sums..............	325·5	322·1	3·4	228·8	258·2	29·4	277·2	290·2	286·4	294·7
Mean..............	46·5	46·	·5	32·7	36·9	4·2	39·6	41·5	40·9	42·1

(3) DECEMBER 18TH TO 24TH (INCLUSIVE).

24 hours ending 9 a.m. on	*Max.*		*Diff.*	*Min.*		*Diff.*	*Mean.*		*Temp. at 9 a.m.*	
	W.P.	*O.R.*		*W.P.*	*O.R.*		*W.P.*	*O.R.*	*W.P.*	*O.R.*
Sun. Dec. 18....	52·5	52·3	0·2	44·8	46·8	2·0	48·7	49·6	50·5	50·0
Mon. ,, 19....	57·7	52·9	4·8	47·2	48·5	1·3	52·5	50·7	47·7	48·3
Tues. ,, 20....	51·9	49·0	2·9	40·4	43·2	2·8	46·2	46·1	41·5	43·2
Wed. ,, 21....	48·4	46·3	2·1	41·0	43·2	2·2	44·7	44·8	43·7	45·3
Thur. ,, 22....	49·1	46·0	3·1	35·0	37·7	2·7	42·1	41·9	37·4	38·5
Fri. ,, 23....	47·3	44·2	3·1	32·1	34·5	2·4	39·7	39·4	36·5	37·4
Sat. ,, 24....	39·4	38·9	0·5	28·4	30·3	1·9	33·9	34·6	29·1	30·8
Sums..............	346·3	329·6	16·7	268·9	284·2	15·3	307·8	307·1	286·4	293·5
Mean..............	49·5	47·1	2·4	38·4	40·6	2·2	44·0	43·9	40·9	41·9

(4) DECEMBER 25TH TO 31ST (INCLUSIVE).

24 hours ending 9 a.m. on	*Max.*		*Diff.*	*Min.*		*Diff.*	*Mean.*		*Temp. at 9 a.m.*	
	W.P.	*O.R.*		*W.P.*	*O.R.*		*W.P.*	*O.R.*	*W.P.*	*O.R.*
Sun. Dec. 25....	33·6	33·9	–0·3	27·3	27·2	–0·1	30·5	30·6	30·8	29·0
Mon. ,, 26....	37·3	34·8	2·5	17·1	21·0	3·9	27·2	27·9	18·1	22·2
Tues. ,, 27....	32·6	27·6	5·0	14·7	20·0	5·3	23·7	23·8	16·2	20·9
Wed. ,, 28....	28·9	26·4	2·5	15·3	20·4	5·1	22·1	23·4	16·5	21·0
Thur. ,, 29....	31·5	30·0	1·5	16·2	21·0	4·8	23·9	25·5	24·3	24·8
Fri. ,, 30....	36·2	35·8	0·4	23·6	24·6	1·0	29·9	30·2	26·6	29·1
Sat. ,, 31....	35·8	35·3	0·5	22·7	27·1	4·4	29·3	31·2	34·9	35·2
Sums	235·9	223·8	12·1	136·9	161·3	24·4	186·6	192·6	167·4	182·2
Mean	33·7	32·0	1·7	19·6	23·0	3·4	26·7	27·5	23·9	26·0

(5) JANUARY 1ST, 1893, TO 7TH (INCLUSIVE).

24 hours ending 9 a.m. on	*Max.*		*Diff.*	*Min.*		*Diff.*	*Mean.*		*Temp. at 9 a.m.*	
	W.P.	*O.R.*		*W.P.*	*O.R.*		*W.P.*	*O.R.*	*W.P.*	*O.R.*
Sun. Jan. 1. ...	36·8	35·3	1·5	24·9	26·8	1·9	30·9	31·1	26·2	27·1
Mon. ,, 2. ...	32·9	31·7	1·2	22·0	22·0	...	27·5	26 9	23·0	23·0
Tues. ,, 3. ...	33·4	33·4	. .	17·8	22·2	4·4	25·6	27·8	33·4	33·4
Wed. ,, 4. ...	35·1	34·3	0·8	12·4	21·0	8·6	23·8	27·7	13·1	21·0
Thur. ,, 5. ...	20·0	28·8	–8·8	8·8	19·7	10·9	14·4	24·3	16·7	27·4
Fri. ,, 6. ...	32·3	33·0	–0·7	16·2	27·5	11·3	24·3	30·3	30·2	32·1
Sat. ,, 7. ...	32·8	32·7	0·1	29·0	30·0	1·0	30·9	31·4	31·5	31·6
Sums.	223·3	229 2	–5·9	131·1	169·2	38·1	177·4	199·5	174·1	195·6
Mean.	31·9	32·7	–0·8	18·7	24·2	5·5	25·3	28·5	24·9	27·9

(6) January 8th to 14th (inclusive).

24 hours ending 9 a.m. on	*Max.* *W.P.*	*O.R.*	*Diff.*	*Min.* *W.P.*	*O.R.*	*Diff.*	*Mean.* *W.P.*	*O.R.*	*Temp. at 9 a.m.* *W.P.*	*O.R.*
Sun. Jan. 8....	35·8	35·0	0·8	31·1	28·8	—2·3	33·5	31·9	35·1	35·0
Mon. ,, 9....	37·8	37·2	0·6	34·4	34·3	—0·1	36·1	35·8	37·0	36·5
Tues. ,, 10....	38·7	38·0	0·7	35·2	35·3	0·1	36·9	36·7	38·5	38·0
Wed. ,, 11....	40·7	39·0	1·7	31·6	32·4	0·8	36·2	35·7	37·0	36·6
Thur. ,, 12....	39·9	38·8	1·1	34·6	34·7	0·1	37·3	36·8	36·1	37·5
Fri. ,, 13...	40·8	39·5	1·3	35·0	35·6	0·6	37·9	37·6	36·9	36·4
Sat. ,, 14....	41·8	41·1	0·7	32·6	33·8	1·2	37·2	37·4	35·4	35·1
Sums	275·5	268·6	6·9	234·5	234·9	0·4	255·1	251·9	256·0	255·1
Mean	39·4	38·4	1·0	33·5	33·6	0·1	36·4	36·0	36·6	36·4

(7) January 15th to 21st (inclusive).

24 hours ending 9 a.m. on	*Max.* *W.P.*	*O.R.*	*Diff.*	*Min.* *W.P.*	*O.R.*	*Diff.*	*Mean.* *W.P.*	*O.R.*	*Temp. at 9 a.m.* *W.P.*	*O.R.*
Sun. Jan. 15. ..	37·0	36·2	0·8	25·5	27·8	2·3	31·3	32·0	26·4	28·0
Mon. ,, 16....	34·2	34·9	—0·7	26·1	28·0	1·9	30·2	31·5	34·2	34·9
Tues. ,, 17....	42·0	41·0	1·0	33·5	34·3	0·8	37·8	37·7	35·1	35·8
Wed. ,, 18....	43·5	44·0	—0·5	32·6	34·1	1·5	38·1	39·1	43·2	44·0
Thurs. ,, 19....	48·0	46·0	2·0	37·1	41·1	4·0	42·6	43·6	37·6	42·2
Fri. ,, 20....	46·2	45·2	1·0	36·0	38·1	2·1	41·1	41·7	36·7	38·5
Sat. ,, 21....	45·7	43·0	2·7	35·6	37·2	1·6	40·7	40·1	40·1	39·4
Sums.	296·6	290·3	6·3	226·4	240·6	14·2	261·8	265·7	253·3	262·8
Mean	42·4	41·5	0·9	32·3	34·4	2·1	37·4	38·0	36·2	37·5

(8) January 22nd to 28th (inclusive).

24 hours ending 9 a.m. on	*Max.* *W.P.*	*O.R.*	*Diff.*	*Min.* *W.P.*	*O.R.*	*Diff.*	*Mean.* *W.P.*	*O.R.*	*Temp. at 9 a.m.* *W.P.*	*O.R.*
Sun. Jan. 22....	44·8	43·0	1·8	39·8	39·3	—0·5	42·3	41·2	43·2	43·0
Mon. ,, 23. .	50·3	46·0	4·3	42·9	42·6	—0·3	46·6	44·3	45·5	45·4
Tues. ,, 24....	49·0	47·8	1·2	44·2	45·0	0·8	46·6	46·4	45·0	45·5
Wed. ,, 25....	52·0	49·2	2·8	35·5	40·4	4·9	43·8	44·8	37·4	41·8
Thurs. ,, 26....	49·5	47·1	2·4	37·4	40·3	2·9	43·5	43·7	42·6	45·0
Fri. ,, 27....	47·8	45·2	2·6	28·9	34·1	5·2	38·4	39·7	32·0	35·5
Sat. ,, 28....	49·0	44·9	4·1	31·7	35·6	3·9	40·4	40·3	37·9	38·4
Sums.	342·4	323·2	19·2	260·4	277·3	16·9	301·6	300·4	283·6	294·6
Mean	48·9	46·2	2·7	37·2	39·6	2·4	43·1	42·9	40·5	42·1

SUMMARY OF WEEKLY MEANS.

	SHADE.									
	Max.			*Min.*			*Mean.*		*Temp. at 9 a.m.*	
	W.P.	*O.R.*	*Diff.*	*W.P.*	*O.R.*	*Diff.*	*W.P.*	*O.R.*	*W.P.*	*O.R.*
Dec. 4—10. ...	38·5	37·7	0·8	23·8	27·6	3·8	31·2	32·7	29·8	31·6
,, 11—17. ...	46·5	46·0	0·5	32·7	36·9	4·2	39·6	41·5	40·9	42·1
,, 18—24. ...	49·5	47·1	2·4	38·4	40·6	2·2	44·0	43·9	40·9	41·9
,, 25—31. ...	33·7	32·0	1·7	19·6	23·0	3·4	26·7	27·5	23·9	26·0
Jan. 1—7. ...	31·9	32·7	−0·8	18·7	24·2	5·5	25·3	28·5	24·9	27·9
,, 8—14. ...	39·4	38·4	1·0	33·5	33·6	0·1	36·4	36·0	36·6	36·4
,, 15—21. ...	42·4	41·5	0·9	32·3	34·4	2·1	37·4	38·0	36·2	37·5
,, 22—28. ...	48·9	46·2	2·7	37·2	39·6	2·4	43·1	42·9	40·5	42·1
Sums	330·8	321·6	9·2	236·2	259 9	23·7	283·7	291·0	273·7	285·5
Mean	41·4	40·2	1·2	29·5	32·5	3·0	35·5	36·4	34·2	35·7

I. *Maxima.*

Generally speaking, the maxima at Whitworth Park are higher than the corresponding readings at Oldham Road, the daily average for the period in question at the former observatory being 41°·4, and at the latter 40°·2. In this connection it may be noted that during the month of January 17hrs. 20min. of bright sunshine were registered at Whitworth Park, as compared with 10hrs. 45mins. during the corresponding period at Oldham Road, although it must be pointed out that for January there does not appear to be any connection between the differences in the maxima and the differences in the amount of bright sunshine on a given day. The greatest divergence—8°·8—between the maxima occurs on Jan. 5th.

Percentage of Maxima greater at Whitworth Park than at Oldham Road.

Percentage of	higher	readings	observed ...	...	82·
,,	equal	,,	,, ...	...	70·
,,	higher	,,	calculated	...	86·

The calculated percentage is obtained by assuming that in half the cases in which the readings were equal, the temperature was really higher in the Park maximum than in the Oldham Road maximum.

II. *Minima.*

The minima show a much greater difference than do the maxima, the daily average being 29·5 and 32·5 at Whitworth Park and Oldham Road respectively. The days marked by the greatest divergences are December 5, December 6, January 4, January 5, and January 6, these being also the days of greatest cold.

Date.	Difference between Minima.	Minimum Reading at Whitworth Park.
Dec. 5	8°·0	17·2
„ 6	6°·0	19·8
Jan. 4	8·6	12·4
„ 5	10·9	8·8
„ 6	11·3	16·2

The coldest week at Oldham Road was Dec. 25—31, the daily average for the minima being 23°·0, whereas the coldest week at Whitworth Park was the following week, the daily average being 18°·7.

Percentage of Minima Readings lower at Whitworth Park than at Oldham Road.

Percentage of lower readings observed	... ...	89·
„ equal „ „	... ...	2·
„ lower „ calculated	... ...	90·

III. *Means.*

68 per cent. of the means are higher at Oldham Road than at Whitworth Park, the daily averages being 36·4 and 35·5 respectively.

IV. *9 a.m. Readings.*

Generally speaking, the readings at Whitworth Park are lower than at Oldham Road, the daily averages being 34·2 and 35·7 respectively.

Percentage of lower readings observed			... ...	88·
„	equal „	„	... ...	2·
„	lower „	calculated...	...	89·

Mean Daily Range.

The mean daily range is less at Oldham Road than at Whitworth Park, the values being respectively 7°·7 and 11°·9.

Taking the series of readings as a whole the greatest divergence occurs on January 5th, the figures for the day being:—

	Maximum in shade.	Minimum.	Mean.	9 a.m. Readings.
Whitworth Park..	20°·0	8·8	14·4	16·7
Oldham Road...	28·8	19·7	24·3	27·4
Difference	8·8	10·9	9·9	10·7

Note on the previous paper. By Arthur Schuster, Ph.D., F.R.S., F.R.A.S.

Mr. Wilson, a few weeks ago, drew my attention to a curious difference in the record of the minimum temperature as observed in the City Observatory, Oldham Road, and the Owens College Observatory, Whitworth Park. I asked him to write a short account of his observations, because it seemed to me that, although the time over which the observations extend is short, the results were definite, and suggested several matters to which our attention will have to be directed in future.

The remarkable differences which appear in the temperature records in different parts of the city furnish an additional proof, if proof were wanted, that observations taken in or near a large town cannot be taken to represent correctly the meteorological character of the surrounding districts, but it by no means follows that these observations are of no value. On the contrary, they may lead to some important conclusions on what may be called town weather as distinguished from country weather.

It seems to me that the differences in the minimum temperatures are accounted for by the fact that the smoke hanging over the city prevents a free radiation into space at night. The smaller the amount of dust and smoke the lower would be the minimum temperature. The effect of smoke is so considerable that the differences between the Oldham Road and Whitworth Park observations amount, as Mr. Wilson has shown, in some cases to 11 degrees, and it would be interesting to have some records still nearer the centre of the city.

The lessening of cold in winter nights might not seem at first sight to be an object for regret, but it must be remembered that the same cause which shelters the town against the effects of radiation, will prevent the sunlight from having its due effect in daytime. Consequently, in the month of January, Oldham Road only registered 62% of the sunlight registered at Whitworth Park; and here it must again be remembered that the Oldham Road Observatory is not near the centre of the city, nor is the Whitworth Park very far removed from it. How much greater, then, may we expect to find the differences existing between the centre of the town and the country.

The effect of smoke seems so considerable, and its effects appear so rapidly, that there is a marked difference in the behaviour of the Oldham Road Observatory on Sundays and other days. I was struck by the fact that on only 5 occasions did the Oldham Road Observatory record lower temperatures than the Whitworth Park, and all five cases happened during the night from Saturday to Sunday, or from Sunday to Monday. I have arranged Mr. Wilson's record according to the days of the week, and the result is shewn in the following table.

Night from.	Difference in the mean record of minimum temperature at Oldham Road and Whitworth Park.
Saturday to Sunday	1·25
Sunday to Monday	2·16
Monday to Tuesday	3·13
Tuesday to Wednesday ...	3·53
Wednesday to Thursday ...	3·91
Thursday to Friday	3·86
Friday to Saturday	2·94

No very certain conclusions can be drawn from the record of a few weeks only, but it is certainly suggestive that while the mean difference on Saturday and Sunday nights is 1°·7 only, the mean difference during the rest of the week is double that number, or 3°·4.

In future observations attention will be directed to these differences as depending on the general state of the atmosphere. In conclusion, I should like to state that I shall be glad to receive the names of gentlemen residing in different parts of Manchester who would volunteer to take regular records, especially of sunshine, the instruments being supplied to them.

On the Length of Flame Produced by the Explosion of Gases in Tubes. By B. Lean, B.Sc., Dalton Chemical Scholar; and H. B. Dixon, M.A., F.R.S., Professor of Chemistry in the Owens College.

(*Received February 21st, 1893.*)

While many measurements have been made on the pressures produced by the explosion of gases, and also on the rates with which the flame is propagated in different mixtures, we know of few experiments on the *extension* of the flame, *i.e.*, the distance to which the flame may be forced beyond the original limit of the explosive gases.

In a paper, read before this Society in 1891,* we described some experiments on the transmission of flame across an air-gap between two explosive mixtures of gases. We found that the enclosed air was, to a large extent, pushed bodily forward like a plug, so that a comparatively short column of inert gas prevented the flame from penetrating to and igniting the explosive mixture beyond. In the present series of experiments we made observations on the distance to which the flame extended along a tube communicating at one end with the column of explosive gases, and at the other end open to the air. Our main object being to obtain data as to the extension of flame in the explosion of mixtures of fire-damp and air in mines, we used (instead of electrolytic gas, as in our former experiments) various mixtures of air and of coal-gas, which resembles fire-damp in its mode of burning with air.

In the great majority of the experiments, the explosive mixture was introduced into a brass tube, about 2ft. in length and of 15 mm. internal diameter. At one end it was

* *Memoirs Lit. and Phil. Soc.* [Fourth Series], Vol. V., p. 16.

closed by a massive steel tap, the bore of which was also 15 mm. in diameter; this tap carried a by-pass. At the other end was a firing-piece closed by a steel tap. The length of the column of explosive gases in the case of the above tube was 73·5 cm.

The explosive mixture was made and stored in an iron gas-holder over water. To fill the tube, the tap was connected with the gas-holder, and the air in the tube expelled through the by-pass. In every case, one-tenth of a cubic foot was sent through the tube, before the taps were closed, so as to ensure the removal of all air. After every explosion, the products were expelled by a current of air before refilling.

The flash had to travel 6 cm. before it could be seen beyond the end of the steel tap.

To this steel tap glass tubes could be attached by means of cement. They had the same internal diameter as the brass firing tube. Four different lengths were employed:—

tube *b*;	length of air column		36·0	cm.
,, *c*	,,	,,	89	,,
,, *d*	,,	,,	155	,,
,, *e*	,,	,,	240	,,

Experiments were also made in which no glass tube was attached. These we may class under the letter *a*: in these the length of the air column was 6 cm. The point which the flash reached was noted by the eye: with practice this could be done within 1 centimeter. In every case 10 experiments were made under precisely the same conditions: such large differences were found between the results of similar experiments, that unless the mean of a considerable number had been taken, it would have been impossible to arrive at any generalisation.

With each mixture of coal-gas and air experiments were made with several lengths of glass tubing attached to the firing tube.

(1) *1 volume of coal-gas with 4 volumes of air.*

This mixture could not be exploded in the firing tube.

(2) *1 volume of coal-gas with 5 volumes of air.*

The linear extension of the flame is stated in centimetres.

	a.	*b.*	*c.*	*d.*
	less than 6 cm.	less than 6 cm.	less than 6 cm.	less than 6 cm.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
	do.	do.	do.	do.
Mean	do.	do.	do.	do.

(3) *1 volume of coal-gas with 6 volumes of air.*

	a.	*b.*	*c.*	*d.*
	< 6 cm.	40 cm.	81 cm.	74 cm.
	9½	< 6	84	94
	10	< 6	91	86
	12	< 6	60	90
	<6	30	61	73
	9	< 6	85	70
	<6	40	54	71
	11	39	31	50
	8	41	82	102
	<6	< 6	84	82
Mean...	7·9	31·5	71·3	79·2
Max. ...	12	41	91	102
Mim...	<6	< 6	31	50

Note.—In calculating the mean, < 6 cm. is reckoned as 5 cm.

(4) *1 volume of coal-gas with 7 volumes of air.*

	a.	*b.*	*c.*	*d.*
	12 cm.	42 cm.	80 cm.	71 cm.
	14	37	75	71
	13	43	74	82
	13	36	86	88
	13	43	52	85
	12	37	68	86
	12·5	42	87	92
	13	44	89	52
	13	42	88	105
	12	44	58	91
Mean...	12·7	41	75·7	82·3
Max. ...	14	44	89	105
Min. ...	12	36	52	52

(5) *1 volume of coal-gas with 8 volumes of air.*

	a.	*b.*	*c.*	*d.*	*e.*
	11 cm.	38 cm.	62 cm.	83 cm.	82 cm.
	12	35·5	83	71	78
	12	35·5	50	86	81
	10	42	71	81	84
	12	40	55	81	78
	12	44·5	81	82	73
	12	41	86	62	82
	13	43	69	78	105
	13	36	81	73	68
	12	42	87	96	62
Mean ...	11·9	39·7	72·5	79·3	79·3
Max. ...	13	44·5	87	96	105
Min. ...	10	35·5	50	62	62

(6) *1 volume of coal-gas with 10 volumes of air.*

	c.	*d.*	*e.*
	68 cm.	60 cm.	43 cm.
	52	66	88
	75	53	60
	76	76	77
	50	42	62
	83	59	41
	63	68	88
	77	52	65
	77	64	40
	64	80	51
Mean ...	68·5	62·4	61·5
Max. ...	83	80	88
Min. ...	50	42	40

(7) *1 volume of coal-gas with 12 volumes of air.*

	c.	*d.*
	42 cm.	35 cm.
	40	36
	44	34
	49	85
	39	39
	64	65
	53	51
	55	39
	36	40
	38	22
Mean...	46·0	44·6
Max. ...	64	85
Min. ...	36	22

(8) *1 volume of coal-gas with 14 volumes of air.*

	b.	*c.*	*d.*
	36 cm.	32 cm.	10 cm.
	19	36	<6
	35	18	23
	20	17	16·5
	31	29·5	30
	25	29	12·5
	17	34	<6
	26	25	32
	41	34	<6
	36	30	35
Mean ...	28·6	28·4	17·4
Max. ...	41	36	35
Mix. ...	17	17	<6

(9) *1 volume of coal-gas with 16 volumes of air.*

With *a*, *b*, *c*, and *d*, the mixture was fired at the upper end of the tube, but the flame was extinguished before the end of the gaseous column was reached.

Below we tabulate the mean extension of the flame in centimetres along the several tubes, for the various explosive mixtures, disposed in a column 73·5 cm. in length. Each number in this table is the mean of 10 experiments.

Explosive Mixture. 73·5 cm.	*a.* 6 cm.	*b.* 36 cm.	*c.* 89 cm.	*d.* 155 cm.	*e.* 240 cm.
1 coal-gas & 4 air	not fired	not fired	not fired	not fired	—
" 5 "	< 6	< 6	< 6	< 6	—
" 6 "	7·9	21·5	71·3	79·2	—
" 7 "	12·7	41·0	75·7	82·3	—
" 8 "	11·9	39·7	72·5	79·3	79·3
" 10 "	—	—	68·5	62·4	61·5
" 12 "	—	—	46·0	44·6	—
" 14 "	—	28·6	28·4	17·4	—
" 16 "	0·0	0·0	0·0	0·0	0·0

To confirm the conclusions arrived at, a few experiments were made with a longer column of the explosive mixture. A brass tube, 4 feet in length, was substituted for the former one, which was 2 feet in length. In this case the length of the explosive column became 135·5 cm.

Experiments were made employing a mixture of 1 vol. of coal-gas and 7 vols. of air.

	Tube c.	*Tube d.*
	69 cm.	94 cm.
	<6	90
	66	158
	78	135
	72	158
	71	80
	<6	68
	91	79
	97	60
	97	48
Mean ...	65·1 cm.	97·0 cm.

It will be observed that great differences exist between individual experiments: vibrations are set up of large amplitude, which in the case of the tube *c* may almost totally prevent the appearance of any flash beyond the tube. If, however, we select those experiments in which the éxtension of the flame is greatest, we find that it exceeds by very little the length of the explosive mixture.

The following are the *chief deductions* which may be drawn from these experiments :—

(1) The mixture containing 1 volume of coal-gas with 7 of air gives the most violent explosion, and with it the projection of the flame along a tube is the greatest.

(2) With mixtures containing 1 volume of coal-gas with not more than 8 volumes of air, the extension of the flame increases with the length of the tube up to a certain limit;

but beyond a certain length of tube, any increase in its length does not affect the projection of the flame.

(3) With mixtures containing more than 8 volumes of air and 1 volume of coal-gas, a large increase in the length of the tube attached appears to *diminish* the extension of the flame.

(4) The mean projection of the flame under the most favourable conditions is little more than equal to the length of the column of explosive gases. Thus, in the case of a mixture of 1 volume of coal-gas and 7 volumes of air, disposed in a column 73·5 cm. in length, the mean extension was 82·3 cm. along a tube 155 cm. in length.

The maximum projection of the flame observed was 105 cm. with the shorter firing-tube, and 158 cm. with the longer firing-tube. In no case was the flame projected one and a half times the length of the column of explosive gases.

Ordinary Meeting, March 7th, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. F. J. FARADAY, F.L.S., F.S.S., read a paper "On Some Remarks by the Right Honourable William Ewart Gladstone, M.P., on the Relative Stability of Gold and Silver as Standards of Value."

A discusssion ensued, in which Professor OSBORNE REYNOLDS, Professor SCHUSTER, and Dr. SCHUNCK took part.

On some Remarks by the Right Honourable William Ewart Gladstone, M.P., on the relative stability of Gold and Silver as Standards of Value; being a vindication of the opinions of Ricardo and Cobden. By F. J. Faraday, F.L.S., F.S.S.

(*Received March 7th, 1893.*)

It is well known that a former esteemed member of the Manchester Literary and Philosophical Society, the late Professor W. Stanley Jevons, wrote much on the value of gold, his special interest in the subject being a consequence, probably, of his employment in very early life, before his association with the Owens College, as assayer to the Sydney Mint. In 1863 he published the results of an exhaustive investigation under the title, "A Serious Fall in the Value of Gold ascertained, and its Social Effects set forth." In this paper, Mr. Jevons arrived at the conclusion that, owing to the Californian and Australian gold discoveries, gold was depreciated 29% in 1857, and that at the period at which he was writing, the average depreciation had been about 9 %; and he predicted that, within the next six years, there would be an average depreciation of from 40 to 50%. As Professor Foxwell has pointed out, Mr. Jevons, in arriving at this latter conclusion, overlooked the stimulating influence of advancing prices on scientific discovery, mechanical invention, productive industry, and trade. In a paper published in 1869, the year before the considerable disturbance caused by the series of events of which the Franco-German War was the first, he demonstrated that gold was depreciated 16 to 18%. Now, in his speech in the House of Commons on February 28, 1893, on Sir Henry Meysey Thompson's motion respecting the

Brussels International Monetary Conference, Mr. Gladstone stated that all these opinions had been abandoned, and that gold during that time of "severe trial" was only depreciated 3 per cent., whereas, according to the right honourable gentleman, the value of silver had varied 40 per cent. within the last 20 or 30 years. Mr. Jevons's first paper on the subject of gold was read before the Manchester Literary and Philosophical Society, and the reputation of Mr. Gladstone as a Finance Minister gives a very great importance to his utterances on such a subject. The question is a scientific and not a political one, and as the Society has already admitted to its *Memoirs* two papers relating to it, one by Mr. Jevons in 1859 (*Memoirs*, Vol. I., 3rd Series), and one by the present writer in 1891 (*Memoirs and Proceedings*, Vol. IV., 4th Series), I trust that a further communication on a problem of extreme economic interest will not be considered out of place.

Mr. Gladstone's argument, as reported by the *Times*, was as follows:—"I am not exaggerating when I say that not only the ignorant herd, but many men of sense, and practical men who were high authorities on questions of economy, believed firmly about 40 or 45 years ago that gold was depreciated 20 per cent. I might mention a few names. There was the late Viscount Cardwell, as good an economist as I have ever known among purely political men; there was Mr. Cobden, who, in addition to his other great gifts and powers, undoubtedly stood very high as a political economist; and there was a distinguished friend of Mr. Cobden, M. Chevalier, who published a book, the main proposition of which was that gold had undergone a real depreciation of 20 per cent. All that has blown over now, and nobody believes at present in any such depreciation. It happened, too, at that period, that silver was in a state of considerable steadiness, and afforded a very fair test of values in the market. I think I am right in saying that silver then rose from 5s. to 5s. 3d. per ounce, and that gold fell about 3 per cent. That was a most severe trial, and there is no epoch in history, not even in the 16th century—when such remarkable changes were produced by the discovery of America—when so vast and enormous an addition had been made, almost at a moment's notice, to the monetary transactions of the world, and to the necessity thereby created for an enlargement of the circulating medium. Yet gold has stood, and has not varied more than about 3 per cent. I should say that is a very respectable case to make out for gold as a circulating medium. If, under such pressure and such an agony of trial, the fluctuation of gold amounted to only a trifle, the position of gold as a standard of value is splendidly demonstrated. It is now proposed that silver shall be used as a circulating medium, but what has been the case with regard to silver? The supply of silver appears to be subjected to more extraordinary variations than any ever known in the case of gold. The variation in the value of silver within the last 20 or 30 years is not less than 40 per cent. . . . . Am I right in contending that fixity is the proper requirement of a standard of value? If it is, I want to know how you can improve that standard of value which, under the severest circumstances, has never varied more in this country than 3 per cent. or 4 per cent., by associating with it a commodity which has actually varied to the extent of 40 per cent."

It is necessary to point out, for the sake of clearness, that Mr. Gladstone was wrong in fixing the period of the alarm respecting the depreciation of gold as "40 to 45 years" ago, as the longer period would take us back to a time antecedent to the gold discoveries, and the shorter to a time when their effect on prices had not become apparent. The actual period of alarm was from 23 to 35 years ago, when Chevalier, Cobden, and Jevons were inquiring into the subject. Mr. Cobden's translation of Chevalier's book on "The Probable Fall in the Value of Gold," was published in 1859. In the introduction to his translation, Mr. Cobden approvingly referred to a suggestion for the establishment of life insurance companies on the basis of a silver standard, and the fixing of leases and rents in terms of farm produce.

Let us examine the exact figures of the case put by Mr. Gladstone. According to Soetbeer's "Materialien," the production of gold sprang from an average of 54,759 kilos. per annum in the ten years 1841–50, to an average of 195,305 kilos. per annum in the twenty years 1851–70. This was the "agony of trial" for gold to which Mr. Gladstone referred. During the period from 1875 to 1893 the production of silver has increased from an average of 1,654,000 kilos. for the ten years 1866–75, to an average of 2,930,000 kilos. per annum. This has been the time of the "agony of trial" for silver. Mr. Gladstone's contention is, that during the former period gold was depreciated only 3 per cent., while, during the latter, silver has been depreciated 40 per cent.

In dealing with this argument, it must first be pointed out that Mr. Gladstone's statement that "the supply of silver appears to be subjected to more extraordinary variations than any ever known in the case of gold" is not justified by the figures. In the "agony" time of gold the average out-put of that metal was suddenly increased 257 per cent., maintained that increase for twenty years, and then fell off, the average decrease during the subsequent period, 1871–1892, being 17 per cent. During the "agony" time of silver the production of the white metal has increased gradually, and the average increase for the last 17 years, compared with the previous ten years, has been only 77 per cent.

Turning now to the variations in the values of the two metals, the fallacy in Mr. Gladstone's argument lies in the fact that, in both periods, he compares the values of the metals in terms of each other. But such a method may, obviously, give any result according to the point of view of the investigator. If we imagine two elastic spheres, the larger of which at a given point of time is 15½ times the size of the other, and at a later period is 25 times the size, we cannot possibly determine whether the variation is due to the contraction of the one or to the expansion of the other, except by comparison with a third body or group of bodies. Thus, Mr. Gladstone tells us that as 3 per cent. more gold was given for a certain quantity of silver during the first period, gold had depreciated; and that as 40 per cent. less gold is given for the same quantity of silver in the second period, silver has depreciated. There is no reason why we should not say that gold depreciated in one case and appreciated in the other, except in so far as we rest on *a priori* reasoning from variations in production, regardless of any other conditions (such as variation of demand) affecting value.

In stating that during the "agony" period of gold, silver rose from 5s. to 5s. 3d. per oz., Mr. Gladstone is in error. Presumably he refers to the prices in the London market. According to Mr. Stewart Pixley's well-known table showing the monthly fluctuations since 1833 the price of silver during the period in question never rose above 62¾d., and that price was quoted for only a few days in March, 1859, and again for a few days in July of the same year. I have compiled the following table showing the average price of silver in quinquennial periods from 1851–70, the period of maximum Californian and Australian gold production :—

Periods.	*Gold Price of Silver. per oz.*
1851–1855	$61\frac{3}{16}$d.
1856–1860	$61\frac{10}{16}$d.
1861–1865	$61\frac{4}{16}$d.
1866–1870	$60\frac{10}{16}$d.

The average price in 1850, in London, I may remark, was $60\frac{1}{16}$d.

The highest average price for any single year in the whole period was $62\frac{1}{16}$d., in 1859, an average which was not again attained during the whole twenty years, and that extreme rise was only 1·9 per cent. on the par price, $60\frac{7}{8}$d. at the French mint. The next highest annual average during the whole period was $61\frac{3}{4}$d., in 1858, a rise of 1·4 per cent. only. Moreover, it will be observed that the lowest average in the above table for quinquennial periods was that for the last five years, when an increase of 257 per cent. in the out-put of gold had been accumulating for twenty years, a fact which surely demonstrates that variation in production was not a governing condition in determining the relative value of the precious metals. But even if he had given the exact variation in the London market, which, as we have seen, was much less than 3 to 4 per cent. as stated by him, Mr. Gladstone would not have done full justice to the steadiness of gold in terms of silver during that "agony" period. Had he taken the prices in the Paris market he would have found that so far as his test is a good one, gold remained absolutely unaltered during the whole period. There was no time during which both the metals were not sent to the French mint for coinage in the ratio of $15\frac{1}{2}$ to 1; no time when the French silversmith could not obtain silver at the equivalent in French money of $60\frac{7}{8}$d. per oz., neither more nor less. The reason is perfectly obvious; it was the continued free mintage of both metals in that ratio which kept the exchangeable value steady in terms of each other, the variations in the London market being simply equivalent to the costs of sending the metal to or from the open Paris mint, that is, freight, insurance, and interest. Taking Mr. Gladstone's test of stability the conclusion is irresistible that the steadiness of value of gold in terms of silver, during a period of 257 per cent. increase in the production of the yellow metal, was due to the free mintage of both metals at a fixed ratio, and that the enormous divergence of 40 per cent. during a subsequent period of greatly diminished strain in the relative production is a consequence of the abandonment of such free mintage.

In order to ascertain the relative variations of value, however, we must adopt Jevons's plan of testing by the prices of commodities. As regards the "agony" period of gold, Jevons conclusively showed that both silver and gold were depreciated during that period by the increase in their joint volume as money through the gold discoveries in California and Australia. The prices of commodities in gold were raised 16 or 18 per cent., and as the mutual exchangeable value of gold and silver remained steady in the Paris market, and, therefore, practically steady in the London market, both metals were clearly depreciated to the same extent in terms of commodities.

Coming now to the "agony" period of silver I have extended the table testing the two metals by wheat—the favourite standard of Adam Smith and the older economists generally—which I presented to the Society in 1891. In considering absolute variations in the value of either gold or silver, it would, of course, be desirable to take a series of commodities for comparison. But in estimating the relative variation in the purchasing power of the two metals, wheat alone is quite sufficient to yield correct results. In extending my former table, I have worked out also the respective quantities at the average prices of the period 1845–50, before the disturbing influence of the gold discoveries, and prefixed the results to the table as a base line; and I have carried forward the comparison to the present date.

Table showing weights of silver and gold respectively which would exchange for one quarter of wheat in the undermentioned years, calculated according to the average prices in the London market in each year, gold being taken at the Bank of England price of £3. 17s. 9d. throughout.

Year.	Average Gold price of silver per oz.	Gazette average gold price of wheat per qtr.	Weight of silver to 1 qtr. of wheat.	Weight of gold to 1 qtr. of wheat.
	d.		*oz.*	*oz.*
1845-50 *(average)*	$59\frac{1}{2}$	51/7	10·4033	0·6634
1871	$60\frac{1}{2}$	57/-	11·3058	0·7331
1872	$60\frac{5}{16}$	57/-	11·3409	0·7331
1873	$59\frac{1}{4}$	59/-	11·9494	0·7588
1874	$58\frac{5}{16}$	56/-	11·5241	0·7202
1875	$56\frac{7}{8}$	45/2	9·5297	0·5809
1876	$52\frac{3}{4}$	46/2	10·5024	0·5938
1877	$54\frac{13}{16}$	56/9	12·4242	0·7299
1878	$52\frac{9}{16}$	46/5	10·5968	0·5970
1879	$51\frac{1}{4}$	43/10	10·2634	0·5638
1880	$52\frac{1}{4}$	44/4	10·1812	0·5702
1881	$51\frac{11}{16}$	45/4	10·5248	0·5831
1882	$51\frac{5}{8}$	45/1	10·4794	0·5798
1883	$50\frac{9}{16}$	41/7	9·8689	0·5348
1884	$50\frac{5}{8}$	35/8	8·4543	0·4587
1885	$48\frac{5}{8}$	32/10	8·1028	0·4223
1886	$45\frac{3}{8}$	31/-	8·1983	0·3987
1887	$44\frac{5}{8}$	32/6	8·7394	0·4180
1888	$42\frac{7}{8}$	31/10	8·9096	0·4094
1889	$42\frac{11}{16}$	29/9	8·3631	0·3826
1890	$47\frac{11}{16}$	31/9	7·9895	0·4083
1891	$45\frac{1}{16}$	37/-	9·8529	0·4759
1892	$39\frac{3}{16}$	30/3	9·2631	0·3890
1893 *(March 6)*	$38\frac{1}{4}$	26/-	8·1568	0·3344

From this table I have taken certain representative years and the period 1845–50, and, comparing the respective purchasing powers of gold and silver in terms of wheat at to-day's prices with their respective purchasing powers in terms of wheat in each of the years and periods mentioned, I find that both metals have appreciated. I give the results in the following table :—

Table showing the appreciation in the wheat-buying power of gold and silver respectively at the prices in March, 1893, as compared with the wheat-buying power of each metal in the undermentioned years and periods.

Year.	Weight of Silver to 1 Quarter of Wheat.	Weight of Gold to 1 Quarter of Wheat.	Present Appreciation since years or periods indicated.	
			Silver.	Gold.
	oz.	oz.		
Mar. 6, 1893	8·1568	0·3344	...	...
1883-92 Average.	8·7742	0·4298	7%	28%
1875	9·5297	0·5809	17%	74%
1871	11·3058	0·7331	38%	120%
1845-50 Average.	10·4033	0·6634	27%	98%

It will be seen from the above table that the increase in the buying power of gold is to-day very much greater than the increase in the buying power of silver. As I have previously pointed out, an increase in the buying power of the precious metals was to be expected, if only because of the increase of facilities for moving commodities great distances, and the consequent lowering of transport charges, the percentage effect of which on price would of course be greater in proportion to the bulkiness and low value of the commodity. Thus, if we take 1875 as a normal year for wheat, which, in consequence of the Franco-German War and other disturbing influences, was abnormally dear in 1871, then a cheapening of wheat in terms of silver to the extent of 17 per cent. since that year may be explained as a consequence of the opening of the Suez Canal, the extension of railways in India and the United States, and improvements in marine engines, the cheapening influences of which would, of course, be more apparent in the price of a bulky and cheap commodity like wheat than in that of a precious commodity like silver; the cost of carriage being a much more important element in the ultimate value of wheat than in that of silver. On the other hand, an appreciation of 74 per cent. in the wheat value of gold since the same year, is an unanswerable proof that the yellow metal possesses in a far lower degree than silver, that "fixity" of exchangeable value which Mr. Gladstone attributed to it. In comparing with the period 1845-50 we must make allowance for the removal of the corn duties.

It may, however, be suggested that there may be a fallacy in merely comparing the prices of to-day with the several previous years and periods enumerated, as there may have been great fluctuations meanwhile; or, in other words, that a comparison of the prices at various dates with previous periods might give results rather to the disadvantage of silver than gold. I have, therefore, compared the wheat value of each metal in each year and period with its value in the preceding year or period in the table, in order to ascertain whether in each case the appreciation has been more or less steadily progressive. The following table gives the results:—

Table showing the depreciation or appreciation in the wheat-buying power of gold and silver respectively in each of the undermentioned years and periods as compared with the previous year or period in the table.

Year.	Weight of Silver to 1 Quarter of Wheat.	Weight of Gold to 1 Quarter of Wheat.	Depreciation or Appreciation.	
			Silver.	Gold.
	oz.	oz.		
1845-50	10·4033	0·6634	...	...
1871	11·3058	0·7331	Depn. 8%	Depn. 9%
1875	9·5297	0·5809	Appn. 18%	Appn. 27%
1883-92 Average.	8·7742	0·4298	,, 9%	,, 35%
1893 March 6.	8·1568	0·3344	,, 7%	,, 28%

It will be seen that the variation in the wheat-value has been, since 1871, in each instance more extreme in the case of gold than in that of silver ; and that in 1871, before the demonetisation of silver, the wheat value of both metals was depreciated to an approximately equivalent degree, but that silver (taking the price in London where there was no free mintage) was less depreciated than gold.

The figures vindicate Ricardo's prediction that silver would prove a steadier standard than gold, and Cobden's practical recommendation of silver as a standard of deferred payments.

General Meeting, March 21st, 1893.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., Vice-President, in the Chair.

Mr. C. H. SCHILL, Merchant, Manchester, was elected an ordinary member.

Ordinary Meeting, March 21st, 1893.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., Vice-President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. FARADAY exhibited the original manuscript of a proctor's bill of costs in connection with the proving of a will, found by Mr. W. E. Jowitt amongst some Devonshire family papers, and dated January 9th, 1724, as follows:—

Matthew Oliver decede.

	£	s.	d.
ffee - - - - - - - - - -	00	03	4
ffor drawing Instruccons for the Comn and sueing out the same under Seale	00	03	6
ffor attending the Execution thereof and attesting the same as being a Publick Notary	00	03	6
ffor Ing: the Will - - - - - - -	00	08	8
ffor the Collated Copy thereof attested - -	00	06	8
ffor Stampt parchment and paper - - -	00	01	10
ffor sueing out the Probat under Seale - -	00	03	4
ffor Postage and Carr of Letters and parcells	00	05	10
ffor Regring the Will at Worcester & ffee -	00	05	10
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Reced. ye Ninthe Day of Janry 1724 of Mrs. Oliver ye Contents of this Bill, p. me: FRD. SOLLEY. } *05 : 4 : 0*

Mr. WILLIAM THOMSON, F.R.S. Ed., read the following note, "On the Motes in Tobacco Smoke, observed under the Microscope by Mr. FREDERICK HOVENDEN":—

"Mr. Frederick Hovenden recently brought a paper before the Society in which he mentioned the occurrence of motes in tobacco smoke, with wing-like appendages. Mr. Gwyther and others, besides myself, examined tobacco smoke with a view to confirming Mr. Hovenden's observations, but each of us failed to do so. Mr. Hovenden communicated with me further, stating more definitely the manner in which his experiment was made; this experiment I repeated, and succeeded in observing more definitely the appearances which he mentioned. The smoke was blown into a semi-circular cell attached to a microscope slide, which was then closed by a piece of cork or cardboard. The smoke from a cigar or cigarette being blown through a tube into the cell, a considerable quantity of whirling particles was at first observed, but nothing definite until the cell was closed by the cork or cardboard; the whirling then ceased, and the particles or motes came into view, and appeared to move round each other with a vibratory motion, and gradually to fall to the bottom of the cell. I also observed a distinct tail from each mote resembling a shadow going from it in a vertical line behind it. The experiment I made was not done precisely in the manner described by Mr. Hovenden, as there was considerable ground for doubt as to what Mr. Hovenden's conditions exactly were, but I can understand that with a different kind of illumination two shadows or tails might be observed to each mote, which might give the appearance of the wings which Mr. Hovenden mentioned in his paper."

MR. THOMSON successfully repeated the experiment before the members, several of whom saw and described the motes and appendages.

A "Memoir of the late Carl Schorlemmer, LL.D., F.R.S., F.C.S.," by Professor HAROLD B. DIXON, M.A., F.R.S., was read in the absence of the author by Mr. P. J. HARTOG, B.Sc.

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Memoir of the late Carl Schorlemmer, LL.D., F.R.S., F.C.S. By Harold B. Dixon, M.A., F.R.S., Professor of Chemistry at the Owens College.

(Received March 21st, 1893.)

Carl Schorlemmer was born at Darmstadt, in 1834. He studied chemistry in his native town, and afterwards at Giessen. At the age of twenty-four he came to Manchester as private assistant to Professor Roscoe, and three years afterwards was appointed Demonstrator in Chemistry at the Owens College. His first research work, as assistant, was the determination of the composition of the haloid acids when their aqueous solutions were distilled under different pressures. In 1861 he began his investigations on the constitution of the light paraffin oils, which led him to question the accepted view that there were two series of isomeric bodies—the alcohol radicals, *e.g.*, 'methyl,' 'ethyl,' etc., and the hydrides of the radicals, *e.g.*, hydride of ethyl, hydride of butyl, etc.

The researches of Kolbe and Frankland between 1848 and 1850 led to the recognition of several new hydrocarbons. Free "methyl" was obtained by the electrolysis of acetic acid, and by the decomposition of methyl iodide by zinc, and, secondly, a body of similar composition called 'hydride of ethyl' by the action of zinc upon ethyl iodide in presence of water. In 1850 Frankland wrote:—

"I have described two separate series of hydrocarbons isomeric with each other, the one consisting of the bodies which I consider to be alcohol-radicals, and the other containing the members of the marsh-gas family, which I regard, from the mode in which they are formed, as the hydrides of these radicals, thus:

Radicals.		*Hydrides.*		
Methyl	C_2H_3	Methylic hydride		$C_2H_3 \cdot H$
Ethyl	C_4H_5	Ethylic	,,	$C_4H_5 \cdot H$
Propyl	C_6H_7	Propylic	,,	$C_6H_7 \cdot H$
Butyl	C_8H_9	Butylic	,,	$C_8H_9 \cdot H$
Amyl	$C_{10}H_{11}$	Amylic	,,	$C_{10}H_{11} \cdot H$
Etc.		Etc.		

"It is obvious, on inspecting the above columns, that the members on the left hand are in some cases isomeric with others standing below them in the right hand column . . . . It is, therefore, only requisite to establish the *identity* or *isomerism* of 'methyl' and 'ethylic hydride' in order to test the correctness of the two views which have been proposed."

The other view referred to by Frankland had been put forward by Hofmann, and by Laurent and Gerhardt, viz., that "methyl" was really a "methide of methyl" (CH_3CH_3), and identical with "hydride of ethyl." Frankland then proceeded to examine the action of chlorine on 'methyl' obtained by the electrolysis of acetic acid, and to compare the result with the action of chlorine on "hydride of ethyl." With equal volumes of hydrocarbon and chlorine the result appeared the same in each case, but when two volumes of chlorine reacted with one of the hydrocarbons the results appeared different. Frankland drew the conclusion that the hydrocarbons were *isomeric*, and his results were largely accepted by chemists. In 1865 Schorlemmer wrote, "it is now generally believed that two series of hydrocarbons of the formula C_nH_{2n+2} exist, the hydrides and the radicals."

Schorlemmer began his work on the hydrocarbons in 1861 by an examination of the light oils obtained in the distillation of cannel coal. He isolated pentane, hexane, heptane, and octane, and showed that these hydrocarbons formed mono-chlorides by substitution. He concludes his first paper with the words: "There appears, therefore, to be little doubt that the whole series of homologous hydrides are contained in the products of the distillation of coal at low temperatures; and I would venture the suggestion that the so-called paraffins, which are likewise not acted upon by strong acids, may prove to be the higher members of the same series."*

Schorlemmer next showed, in a communication to this Society, that American petroleum contained the same hydrocarbons which he had isolated from cannel-tar. In 1863 he carefully examined the derivatives of heptane from petroleum, and of ethyl-amyl prepared from the iodides of ethyl-amyl. In the following year he proved that equal volumes of chlorine and "methyl" gave, on exposure to light, a volatile liquid boiling at 12°C., which, by analysis and vapour density, he showed to be chloride of ethyl—C_2H_5Cl. He concluded from his experiments that only one series of hydrocarbons existed having the formula C_nH_{2n+2}, but the higher members of the series showed slight physical differences according to the mode of their preparation.

By 1868 the syntheses of various hydrocarbons by Erlenmeyer, Butlerow, Friedel and Ladenburg, and by Schorlemmer himself, led to an important advance. The first three hydrocarbons of the marsh-gas series have no isomers, the higher members may be divided into isomeric groups, according to the mode of combination of the carbon atoms. In the first group the carbon atoms are arranged in a single chain. In the second group one carbon-atom is combined with three others, *i.e.*, the hydrocarbons contain iso-propyl $CH_3.CH.CH_3$. The third group contain iso-propyl *twice;* the fourth group contain a carbon-atom combined with four others. The boiling point of members of the first group is higher than that of the corresponding isomers, and a regular difference in boiling point is shown to exist between the several members of the different

Jour. Chem. Soc., 1862. Vol. XV., p. 427.

groups. From a knowledge of their boiling points Schorlemmer was thus able to classify correctly certain hydrocarbons whose constitution was then unknown.

In the same year he prepared normal propyl alcohol for the first time, and gave a general method of proceeding from the secondary to the normal alcohols.

In an important paper on the structure of the alcohols in 1870, he showed that their constitution could be determined by an examination of their products of oxidation, and he was able to show that when a higher hydrocarbon of the marsh-gas series is treated with chlorine, *a mixture of a primary and of a secondary chloride* results. A careful study of the action of bromine on the paraffins showed (1877) that only secondary mono-bromides were formed.

His later work was mainly on the derivatives of hexane and heptane. He showed that heptane from American petroleum was identical with the heptane discovered by Thorpe in the resin from *Pinus sabiniana*. But the hexane prepared from mannite was shown to differ from the hexane in petroleum, although both must be described as normal paraffins. No explanation has yet been advanced to account for the isomerism of these hexanes.

Of Schorlemmer's other researches the most important are those on "Aurine" and its derivatives, and on "Suberone," made in conjunction with Mr. R. S. Dale.

But Schorlemmer won distinction not only as a brilliant experimenter, but also as an historian and a systematiser of chemical facts. Few chemists have equalled him in his deep and varied knowledge of scientific literature. His "Chemistry of the Carbon Compounds," published in 1874, was the first systematic treatise on modern organic chemistry in the English language, and its clear, yet concise method, makes the work still valuable. His little book, the "Rise and Development of Organic Chemistry" (1879), is original, and full of learning lightly put. He left the well-known

"Treatise" unfinished; but he left the MS. of an "Introduction to the History of Chemistry," which is being prepared for publication.

Schorlemmer was elected a member of this Society in 1870, and served on the Council for several years. He was elected into the Royal Society in 1871. In 1874 a Chair of Organic Chemistry was created for him at the Owens College. He died June 19th, 1892, aged 58.

This short record of Schorlemmer's life cannot be more fitly concluded than by quoting the words of his friend and colleague at the Owens College, Sir Henry Roscoe:—"He was of a retiring, most modest, and unassuming disposition. To only a few of his intimates, German and English, were his true colours visible. As a laboratory teacher he was excelled by few, merely as a lecturer by many. But although, like some other eminent lecturers, his diction may have been faulty, the staple article was there, and I never met a real student amongst all those who passed through his hands who did not express his admiration for the man, and his sense of the obligation which he felt for the masterly instruction Schorlemmer always gave."

LIST OF PAPERS BY PROF. CARL SCHORLEMMER.

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3. On the derivatives of hydride of heptyl. *Chem. Soc. Jour.*, 1863, p. 216.

4. On the chemical constitution of the so-called alcohol radicals. *Chem. Soc. Jour.*, 1863, p. 425.

5. On the action of chlorine upon methyl. *Roy. Soc. Proc.*, 1864, p. 225.

6. On the identity of methyl and hydride of ethyl. *Chem. Soc. Jour.*, 1864, p. 262.

7—13. Researches on the hydrocarbons of the series C_nK_{2n+2}. Parts I., II., III., IV., V., VI. and VII. *Roy. Soc. Proc.*, 1865, 1868, 1870, 1871.

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15. On a new series of hydrocarbons derived from coal-tar. *Roy. Soc. Proc.*, 1866, p. 132.

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17. On ethyl-hexyl ether. *Chem. Soc. Jour.*, 1866. p. 357.

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21. Ueber die Umwandlung der Isopropyl verbindungen in normale Propyl verbindungen. *Zeitschr. f. Ch.*, 1868, p. 49.

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25 Formation of cetyl alcohol by a singular reaction. *Roy. Soc. Proc.*, 1881, p. 22.

26. On aurine. *Chem. Soc. Jour.*, 1871. (With Mr. R. S. Dale.)

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28. Transformation of aurin into rosaniline. *Chem. Soc. Jour.*, 1877 (2), p. 121.

29. Aurin. *Deut. Chem. Ges. B.* XI., p. 708.

30. Aurin. *Deut. Chem. Ges. B.* XI., p. 1556.

31. On aurin. *Chem. Soc. Jour.*, 1879, p. 148.

32. Transformation of aurin. *Chem. Soc. Jour.*, 1879, p. 562.

33. Aurin. *Chem. News*, XXXIX., p. 244.

On the normal Paraffins.

34. Part I. *Phil. Trans*, 1872.

35. Part II. *Phil. Trans.*, 1878.

36. Part III. *Phil. Trans.*, 1880.

37. Part IV. *Phil. Trans.*, 1883. (With Prof. Thorpe.) [Also *Annalen* 217.]

38. The chemistry of the hydrocarbons. *Chem. Soc. Jour.*, 1872.

39. Formula of lead chamber crystals. *Chem. Soc. Jour.*, 1872, p. 627.

40. Normal primary heptyl alcohol. *Roy. Soc. Proc.*, 1873, p. 393. (With Mr. H. Grimshaw.)

41. On the heptanes of petroleum. *Chem. Soc. Jour.*, 1873, p. 319.

42. Oenanthylic acid. *Chem. Soc. Jour.*, 1873, p. 617.

43. Oenanthylic acid and normal heptyl alcohol. *Chem. Soc. Jour.*, 1873, p. 1073. (With Mr. H. Grimshaw.)

44. Methyl-hexyl carbinol. *Chem. Soc. Jour.*, 1874, p. 1029.

45. Suberone. *Chem. Soc. Jour.*, 1874, p. 935. (With Mr. R. S. Dale.)

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49. Remarks on Mr. Morgan's paper on the paraffins from Pennsylvanian petroleum. *Chem. Soc. Jour.*, 1875, p. 306.

50. Mr. Grove's method of preparing chlorides. *Chem. Soc. Jour.*, 1875, p. 308.

51. Isodulcite. *Deut. Chem. Ges. B.* XI., p. 1197.

52. Note on safranine. *Chem. Soc. Jour.*, 1879, p. 682. (With Mr. R. S. Dale.)

53. Suberic and azelaic acids. *Chem. Soc. Jour.*, 1879, p. 683. (With Mr. R. S. Dale.)

54. On the origin of the word chemistry. *Manch. Lit. and Phil. Soc.*, III., 7, 1879.

55. Action of HCl on ethylene alcohol. *Chem. Soc. Jour.*, 1881, p. 143.

56. The phenates of amido bases. *Chem. Soc. Jour.*, 1883, p. 185.

57. Thionyl chloride. *Chem. Soc. Proc.*, 1885, p. 52.

Some recent developments in the application of Salts of Iron to the Purification of Sewage. By Harry Grimshaw, F.C.S.

(Received May 4th, 1893.)

In a previous communication to this Society, I called attention to the action of the perchloride of iron upon the albuminoid bodies which constitute the principal polluting material in sewage and similar waste waters, and showed that the basic perchloride or oxychloride, $Fe_2Cl_6 \cdot xFe_2 3OH$, appears to possess very great precipitating powers in this relation, the action being much quicker and more effectual than that of the normal perchloride Fe_2Cl_6.

In the present communication I give the results of further work in the laboratory, and on the large scale, in relation to the action of the basic salts of iron upon sewage.

There being certain technical points which render the basic persulphate of iron more easy to produce and to manipulate, and also less expensive, attention has been devoted to this salt more especially, in place of the basic perchloride.

With regard to the action of these two substances upon the albuminoid matters of sewage, that of the basic persulphate appears to be even more marked than that of the basic perchloride.

In considering the question of the purification of sewage by the use of the persalts of iron, that is ferric sulphate or ferric chloride, we find, in the first place, that the chief difference between these compounds and the subsulphate (copperas) or subchloride of iron is that the persalts, instead of taking up oxygen from the water or sewage, as do the subsalts of iron, are in the highest possible stage of oxidation, and so are induced, under suitable conditions, to part with their oxygen to the sewage instead of robbing it of its oxygen. This is a very important property, as it is acknowledged on all hands that oxidation of sewage means purification, and it is a significant fact, as will be seen later, that in the presence of oxygen those organisms (bacteria) which, so to speak, burn up and destroy the sewage matters are enabled to flourish, whilst without oxygen, or with a limited supply, the germs of putrefaction and decay are encouraged in their growth; giving in the one case innocuous products, such as carbonic acid gas and water, and in the other carbonaceous and sulphurous gases, which are so dangerous and offensive. The germs of life flourish in the presence of oxygen, those of disease and death in its absence.

The ordinary persulphate $Fe_2(So_4)_3$ and perchloride Fe_2Cl_6 have been used experimentally at different times, the largest trials recently having been carried out at Salford, where the perchloride of iron was used.

In the majority of cases it is necessary to use a certain amount of lime in treating sewage with these salts, but not nearly so much as is the case with sulphate of alumina on "copperas." The precipitation takes place at once, and the rate of subsidence is good, the sulphur compounds are absorbed, and a fair purification effected without filtration. A most exhaustive and accurate comparison of the action of lime, alum, copperas, and persulphate of iron upon sewage was carried out in 1890 by the Massachusetts State Board of Health, whose report is a model research on the sewage question. This investigation into the action of chemical precipitants resulted in the following general conclusions:—

"The lime process has little to recommend it. Precipitation by copperas has produced some satisfactory results. Ferric sulphate and alum are to be preferred to either of the before-mentioned compounds, while chief preference is to be given to ferric sulphate as a precipitant.

"With 1,000 lbs. of alum per million gallons, costing 45 cents per head of population per annum, about 45 per cent. of soluble albuminoid ammonia was removed, 90 per cent. of the bacterial germs, and nearly all the suspended matter.

"With 400 lbs. of ferric oxide in the form of persulphate of iron, costing 44 cents per annum, about 50 per cent. of the soluble albuminoid ammonia was removed, 95 per cent. of the bacteria and all the suspended matter.

"Taking an equal cost per annum, alum removed 29 per cent. and ferric sulphate 41 per cent. of the total impurity."

At the time of making these trials, the Massachusetts Board were not acquainted with the most recent development of the persalts of iron, namely, the basic persalts of iron; that is to say, the chloride or sulphate, preferably the latter, charged with an excess of oxide of iron. The oxide of iron is the real agent in the precipitation and oxidation of the organic matter, and hence the advantage of this form of iron compound. The peculiar nature of these compounds causes them to be very readily split up, and their combination with the foul matters of the sewage is therefore very rapid and complete. The precipitate is also rendered heavier, and a clearer effluent without filtration is obtained. The excess of oxide of iron renders the addition of lime almost entirely unnecessary, which, of course, is advantageous, and causes but little solid matter to be added to the weight of the sewage sludge. A striking experiment showing the difference between the basic and neutral persulphate of iron, is the addition of about one cubic centimetre of a solution of these salts to two cylinders of water (about 500 cc. each). The latter simply colours the water, whilst the iron of the former is immediately deposited out of solution principally as ferric hydrate. The sludge from the basic-iron process possesses very considerable immunity from after decomposition, owing to the presence of the hydrated peroxide of iron, which is the only solid matter which finds its way into the sludge. This body retains the noxious sulphur compounds, and also acts as a carrier of oxygen to the organic matter, which it therefore tends to destroy by a slow process of combustion. That the moist peroxide of iron has this property has been long known to chemists*. It would appear that the basic sulphate of iron fulfils remarkably well the various requirements of a precipitant for sewage, which may be said to be :—

1. Immediate combination with the organic matter of the sewage.
2. Rapid subsidence of precipitate so formed.
3. Power to combine with the sulphur compounds.
4. No tendency to rob the sewage of dissolved oxygen.
5. Powers of oxidation on the organic matter of the sludge.
6. The property of leaving the effluent in a good condition for nitrification to take place during or after filtration.
7. Little addition to weight of sludge.
8. Cheapness.

Below are tables of results of analyses of sewage and waste waters from manufactories which have been treated with this latest development of the iron process at Salford, Derby, Burton, Nuneaton, Astley Bridge, etc. After seeing the results of experimental working at the Salford Sewage Works, that Corporation have decided to apply the basic-iron process to the whole of the sewage.

Average percentage purification at Salford treating 100,000 gallons per day for about 4 months :—Precipitation only, 55 per cent ; with sand filter, 68 per cent ; with

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* "Thorpe's Chemistry," Vol. II., p. 376. "Ferric hydrate is reduced by organic matter in process of decomposition, but in contact with air it is quickly reoxidized, and it thus acts as a carrier of oxygen from the air to the organic matter, and greatly promotes its decomposition. The rapid decomposition of human and woody fibre in many ferruginous soils is thus brought about."

"Watts' Dictionary of Chemistry," Vol. III., p. 58. "In contact with decaying organic matter the ferric hydrates part with oxygen, but take it up again on exposure to air."

ozonite filter, 73 per cent. It should be noted that the above percentages of purification are upon the sewage after settling for 12 to 24 hours, and upon the raw sewage would be some 15 per cent higher. The percentages, therefore, are really of soluble albuminoid ammonia removed.

The Tables appended will explain themselves, and I hope on another occasion to give some further results from the treatment of ten million gallons per day of sewage at the Salford Works.

TABLE I.

Salford Sewage and Effluents, after treatment with Basic Persulphate of Iron. 100,000 gallons treated daily with 15 grains per gallon. Results expressed in parts per 100,000 of Albuminoid Ammonia.

Date. 1892.	(1) Crude Sewage 12 hours settling.	(2) Effluent Unfiltered.	(3) Effluent Filtered Sand.	(4) Effluent Filtered Ozonite.	Per Cent of Purification. (2)	Per Cent of Purification. (3)	Per Cent of Purification. (4)
Not in good working order. { Nov. 28	1·00	0·40	0·30	...	60	70	...
,, 29	0·80	·42	·35	...	47	55	...
,, 30 }	0·75	·40	·29	...	47	61	...
Dec. 1	·75	·31	·22	...	59	70	...
,, 2	·56	·28	·16	...	50	73	..
,, 3	·90	·28	·19	...	69	89	...
,, 4	·85	·35	·25	...	60	70	...
,, 5	·60	·30	·17	...	50	71	...
,, 6	·71	·30	·17	...	57	76	..
,, 7	·75	·32	·22	...	56	71	...
,, 8	·60	·30	·15	...	50	75	...
,, 9	·65	·30	·16	...	53	75	...
,, 11	·59	·28	·15	...	53	73	...
,, 12	·65	·30	·18	...	54	72	...
,, 13	·70	·30	·21	0·18	57	73	74
,, 14	·51	·25	·19	0·135	50	64	73
,, 15	·51	·25	·19	·16	50	62	69
,, 16	·52	·26	·20	·16	50	61	72
,, 17	·62	·28	·19	·15	55	70	75
,, 20	·51	·20	·19	·145	60	64	71
,, 21	·60	·26	·19	·15	56	70	75
,, 22	·60	·26	·21	·18	56	65	70
,, 23	·57	·24	·18	·16	60	68	72
,, 24	·60	·23	·17	·14	60	70	76
Average	0·63	0·29	0·20	0·15	55	68	73

NOTE.—The Crude Sewage, column No. 1, was allowed to settle 12 hours before analysis.

The Effluents, Nos. 2, 3, and 4 were shaken up before analysis.

TABLE II.

Sewage and Waste Water from Manufactories in various districts, before and after treatment. Parts per 100,000 of Alb. Ammonia.

	Mode of Treatment.	Place, &c.	Parts per 100,000 Alb. Amm.			Per Cent. of Purification.	
			Crude Sewage, &c.	Effluent	Filtered through Ozonite.	Effluent Unfiltered.	Effluent Filtered
1	Basic Iron......	Derby	0·8	0·3	0·1	63%	87
2	Basic Iron......	Burton............	1·2	·5	·3	60	75
3	Basic Iron.....	Nuneaton.........	2·01	·43	...	78	...
4	Basic Iron......	Do.	1·8	·51	...	70	...
5	Basic Iron......	Astley Bridge...	0·5	·2	...	60	...
6	Lime	Do. ...	0·5	·31	...	38	...
7	Basic Iron......	Astley Bridge Lime Effluent	0·31	·21	...	30	...
8	Sulphuric Acid	Wool Scourer's Liquor	12·5	1·5	...	88	...
9	Do. and Basic Iron........	Do.	12·5	0·9	0·7	92	94
10	Basic Iron.....	Wool Scourer's Liquor treated with Vitriol ...	1·5	0·9	0·7	40	53
11	Basic Iron......	Felmonger's Liquor	3·0	1·20	·5	60	83
12	Irrigation.......	Hinckley	1·70	·65	...	62	...
13	Basic Iron......	Do.	1·70	·32	...	81	...

No. 8, when treated with vitriol, yielded 8% of fatty matters, 0·4% of vitriol being required. The bulk of the alb. matter is evidently contained in the fatty material (*See* No. 8).

No. 12.—The shaken sewage contained 2·75 of alb. amm. per 100,000.

TABLE III.

Sewage from Hinckley, near Nuneaton. Process of irrigation only. Results of test for Alb. Amm. Parts per 100,000.

	Parts.		Total per cent purification.
Crude sewage before settling... ...	2·75	......	0%
,, ,, after ,, ...	1·70	......	39%
Effluent after irrigation	·65	......	79%
,, ,, precipitation with iron	·32	......	90%
			Purification from soluble albuminoids
Sewage after settling	1·70	......	0%
Effluent after irrigation	·65	......	62%
,, precipitated with iron salt A.	·50	......	70%
,, ,, ,, ,, B.	·45	......	73%
,, irrigation and iron salt ...	·32	......	81%
			Purification from soluble albuminoids.
Effluent after irrigation	·65	......	—
,, ,, ,, and iron salt...	·32	......	70%

This is a bad sewage, but it will be seen that 39% of the impurity is suspended and will settle out by itself, and, therefore, no treatment by land or otherwise should be credited with this part of the purification. Irrigation removed 62% of the soluble albuminoid matters, precipitation by iron removed 73%, whilst precipitation and irrigation together removed the large amount of 81 per cent, the irrigation effluent itself being improved 70%.

TABLE IV.

Results of Treatment of the Sewage of Astley Bridge, near Bolton (180,000 gallons per day) with Basic Persulphate of Iron at the rate of one ton per million gallons, together with 3 cwt. of lime per million gallons.

Date. 1893.	Percentage of Albuminoid Ammonia Removed.			
	Total.		Soluble.	
	Tank Effluent.	Filtered Effluent.	Tank Effluent.	Filtered Effluent.
March 22..	59%	60%	...	...
,, 25...	70	96	...	...
,, 26...	83	91	..	...
,, 28...	78	82	...	...
,, 29...	93	96	...	...
,, 30...	82	86	59%	66%
,, 31...	86	75	64	69
April 1...	88	90	55	60
,, 4...	70	80	54	70
,, 8...	97	98	67	75
,, 10...	93	98	50	87
,, 11...	96	98	76	86
,, 12...	60	82	41	73
,, 13...	84	92	44	72
,, 14...	70	89	28	56
,, 15...	70	85	46	71
,, 16...	80	...	40	...
,, 17...	67	83	42	70
,, 18...	79	89	41	79
,, 19...	86	93	53	75
,, 20...	92	95	68	80
,, 21...	83	89	61	70
,, 22...	93	96	56	75
,, 23...	80	87	50	68
,, 24...	90	94	54	71
,, 25...	94	96	64	76
,, 26...	70	82	40	60
,, 27...	93	97	43	78
,, 28...	80	81	38	70
,, 29...	72	90	30	71
,, 30...	74	...	36	...
May 1...	72	86	47	72
,, 2...	92	96	60	81
	82%	85%	50%	72%

Ordinary Meeting, April 4th, 1893.

JAMES BOTTOMLEY, B.A., D.Sc., F.C.S., Vice-President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Reference was made to the death of Mr. J. S. Crowther, elected a member in 1849.

It being the Easter holiday period the attendance was very small, and after a conversation on some peculiarities of human vision, the meeting was dissolved.

The substance of the following note (received April 6th, 1893), "On the Suspended Impurities in Manchester Water," by Mr. WILLIAM THOMSON, F.R.S.Ed., was brought before the Society at the meeting on December 13th, 1892:—

"No attempt, so far as I know, has been made to determine the quantity of suspended impurities in Manchester water, for the reason that little or none of these impurities will settle, and the ordinary methods of separating them by filtration through filter paper is impossible; *first*, because much of the suspended matter would pass freely through the paper at the beginning of the filtration, and secondly because the pores of the filter paper would soon become blocked up, so that no water would pass through it at all. The quantity of suspended matter in Manchester water is very small, and to obtain reliable figures it is necessary to filter a large quantity of it to obtain a moderate quantity of the solid matter so that it can be weighed and examined. On making some experiments with the Berkefeld filter, which is made of Kieselguhr or fossil earth, I found that the smallest of the microbes, or other particles, were arrested, and the water sterilized. I observed that the water was filtered so rapidly that a large quantity could be passed through the filter in a few hours before it began to get blocked up; thus in one experiment I filtered 36 gallons in 6½ hours, whilst only 24 more were filtered during the following 120 hours (five days). The suspended matter was of a black slimy nature, and on microscopical examination was found to contain bacteria and animalcules, amongst which were diatomaceæ, monads, etc. The water contained from 0·03 to 0·1 grains, *i.e.*, from $\frac{3}{100}$ths to $\frac{10}{100}$ths of a grain per gallon of total suspended matter, of mineral and of organic origin. Sometimes there was a larger quantity of mineral than organic matter, and sometimes the reverse. The following are the figures obtained from the water examined at my laboratory in Princess Street, Manchester:—

	Grains per Gallon—1892.				
	9 Dec.	*10 Dec.*	*26 to 31 Oct.*	*8 Dec.*	*12 Dec.*
Total Solid Matter in suspension	0·1001	0·0386	0·0896	0·0373	0·0610
Which is composed of:—					
Organic Matter, Combined Water, etc....	0·0357	...	0·0292	0·0217	0·0395
Mineral Matter	0·0644	...	0·0604	0·0102	0·0215
Total amount of water filtered (gals.)	17·8	38·0	60·75	35·2	20·5

When a beam of light was passed through the water contained in a large glass globe, before filtration it appeared turbid, the course of the beam of light passing through being well marked; after filtration, however, the water appeared quite free from turbidity, and the course of the beam of light in the filtered water could not be followed.

The filter is made in the form of a candle, and the suspended matter deposits itself on the outside surface, the water being forced through the walls of the candle (which is hollow) runs out of the orifice or tube connected with the interior: the suspended matter is thus left as a slimy deposit on the surface of the candle to the thickness of $\frac{1}{16}$th to an $\frac{1}{8}$th of an inch. This deposit, when washed off, produces an almost black liquid, the black substance from which settles to the bottom, as a black mud in appearance, but on being shaken up rises in the liquid as black clots, which soon break up and distribute themselves equally throughout the water."

Annual General Meeting, April 18th, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

Mr. F. E. BROWN, Mathematical Master, the Hulme Grammar School, Manchester, was elected an ordinary member.

The Annual Report of the Council was presented and amended, and it was moved by Mr. H. GRIMSHAW, F.C.S., seconded by Mr. J. J. ASHWORTH, and resolved :—" That the Annual Report as amended be adopted, and printed in the Society's *Memoirs and Proceedings.*"

It was moved by Dr. G. H. BAILEY, seconded by Mr. W. E. HOYLE, M.A., and resolved :—" That the system of electing Associates of the Sections be continued during the ensuing session."

The following gentlemen were elected Officers of the Society and members of the Council for the ensuing year :—

President.—ARTHUR SCHUSTER, Ph.D., F.R.S., F.R.A.S.

Vice-Presidents.—EDWARD SCHUNCK, Ph.D., F.R.S., F.C.S.; OSBORNE REYNOLDS, M.A., LL.D., F.R.S., &c.; JAMES BOTTOMLEY, B.A., D.Sc., F.C.S.; JAMES COSMO MELVILL, M.A., F.L.S.

Secretaries.—FREDERICK JAMES FARADAY, F.L.S., F.S.S.; REGINALD F. GWYTHER, M.A.

Treasurer.—CHARLES BAILEY, F.L.S.

Librarian.—FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council.—HAROLD B. DIXON, M.A., F.R.S.; ALEXANDER HODGKINSON, M.B., B.Sc.; JOHN BOYD; JOHN F. W. TATHAM, M.A., M.D.; Alderman JOSEPH THOMPSON; FRANCIS JONES, F.R.S. Ed., F.C.S.

Ordinary Meeting, April 18th, 1893.

Professor ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

It was moved by Mr. ALEXANDER HODGKINSON, M.B., B.SC., seconded by Mr. Alderman JOSEPH THOMPSON, and resolved:—"That the Secretaries be requested to forward to Mr. HENRY WILDE, F.R.S., an expression of the respectful sympathy of the members with him in his recent bereavement through the death of Mrs. Wilde."

The following extract from a letter addressed to Dr. SCHUNCK by Mr. FLINDERS PETRIE, with reference to some statements contained in the paper by the former entitled "Notes on some ancient dyes," was read to the meeting:—"Some one has not given very precise information to you about the Egyptian fabrics. The pieces which Mr. Darbishire took from my collection for your purpose were all from Illahun (which is a few miles from Gurob), in Middle Egypt, some 40 miles south of Cairo. Their date is probably the seventh century A.D. They were all from open graves of slight depth (one to three feet) and were the actual clothes of the persons, worn by them during life, in which they were buried, without any coffins or mummification. The dryness of the air and soil has caused the bodies to shrink to a leathery state, with little or no escape of fluids; hence the textiles show but little trace of their contact with the body."

Dr. SCHUNCK stated at the same time that he had received from Mr. Flinders Petrie a specimen of a bright yellow fabric from the same locality as those previously examined. The material he found to be woollen, but the quantity of the fabric placed at his disposal was not sufficient to enable him to identify the colouring matter employed in the production of the dye, not an easy matter under any circumstances in the case of yellow dyes. All he could say was that the mordant employed in dyeing this colour was a mixture of alumina and oxide of iron, and that the dye contained fatty as well as colouring matter.

Mr. HARRY GRIMSHAW, F.C.S., exhibited some varieties of forms of crystallisation of ammonium chloride, under varying conditions of concentration of the solution from which the crystals were obtained, and under varying conditions of temperature and rate of cooling of the liquid. The most interesting, from a technical point of view, was a mass of crystals which had assumed the form and substance of the sublimed ammonium chloride, or sal ammoniac of commerce, as, if it were possible to always obtain this form, the necessity for sublimation might be done away with.

The following note "On the k-partitions of R and of the R-gon" was read by the Rev. THOMAS P. KIRKMAN, M.A., F.R.S. :—

"In my endeavour to complete, as I believe I have completed, what has been hitherto imperfectly done in partitions into a finished theory, I have been most agreeably surprised by the discovery, with satisfactory proof, of the following Theorem:—If k and x be any two numbers, equal or not, and if ${}_k\mathfrak{R}_x$ stand for the sum of all possible permutations of ${}^k\underset{\sim}{Q}$ the k-partitions of x, whose parts are positive or zero and may be repeated—then

$${}_k\mathfrak{R}_x = \text{the } k^{th} \text{ coefficient in } (1+1)^{x+k-1}$$

e.g., $x=5$, $k=3$, the 3-partitions of 5,

$$005,\ 113,\ 221,\ 014,\ 023 = {}_3Q_5,$$

whose permutation symbols are

$$3 \cdot aab + 2abc,$$

give, as products of partitions and their permutations,

$$_3\mathfrak{R}_5 = 3 \cdot 3 + 2 \cdot 6 = 21,$$

which is the third coefficient in

$$(1+1)^{5+3-1} = 1 + 7 + 21 + \ldots .$$

Again,

$$\begin{array}{cccc} \cdot 000005 & 000014 & 000113 & 111002 \\ 11110 & 000023 & 000221 & \end{array} = {}_6Q_5$$

are the 7 6-partitions of 5, whose permutation symbols are, indices being read as multipliers,

$$2a^5b + 2a^4bc + 3a^3b^2c,$$

giving the product,

$$_6\mathfrak{R}_5 = 2 \cdot 6 + 2 \cdot 30 + 3 \cdot 60 = 252,$$

which is the 6th coefficient in

$$(1+1)^{5+6-1} = 1 + 10 + 45 + 120 + 210 + 252 + \ldots$$

"These examples, even if they were a thousand, are no rigorous proof of the above theorem. We require a non-tentative demonstration. Such a one I have, but it pleases me neither by its brevity nor by its elegance. I content myself, for the present in this brief abstract, with begging the aid of mathematicians in finding a neater proof before trial, for every x and k, or, if possible, a disproof.

"This theorem, sent by me without demonstration, appeared in the *Educational Times* in August last. My study of these permutations of the partitions of the number R has given me the mastery of a far more difficult problem, the k-partitions of the R-gon. I shall soon have the honour to present to this Society the correct answer to the following question :—

"In how many different ways, symmetric or not, can an R-gon be partitioned by $k-1$ diagonals, none crossing another, into k faces, viz., into a_3 triangular, a_4 4-gonal, a_5 5-gonal, &c., &c., faces, so that a diagonal or diagonals shall occupy every angle of the R-gon, except the vertices of m marginal triangles, $m <$ or $= a_3$?

"Has any mathematician observed that, forty years ago in these *Memoirs* (Vol. XII., 1853-4, p. 129), appeared a demonstrated formula of three terms, by which the tabulation to any extent of ${}_kP_x$ (the k-partitions of x, from which zero parts but not repetitions are excluded) is made an easier task than any yet invented for little boys in Algebra or Arithmetic? No number is therein required to be written which is not the exact sum of two given numbers already entered in their places. The expression of ${}_7P_x$ in x, in the paper above quoted, was a superfluous exhibition of brute force. Its author had the pleasure of knowing that, whenever and so far as the numbers ${}_kP_x$, $k<x$, are wanted, they will be rapidly tabled by his formula. There is a similar formula of three terms for the tabulation, if required, of the numbers ${}_kQ_x$; but these can be instantly obtained from the table of ${}_kP_x$, as can also the numbers of the partitions in which no part is repeated."

A paper entitled "Notes on a small collection of plants made by Mr. J. Cardwell Lees in South-west Colorado," by JAMES COSMO MELVILL, M.A., F.L.S., was also read.

Notes on a small collection of Plants, collected in S. W. Colorado, by Mr. J. Cardwell Lees. By James Cosmo Melvill, M.A., F.L.S.

(*Received April 18th, 1893.*)

From April till August, 1892, Mr. Cardwell Lees, of Alkrington Hall, Middleton, was one of a surveying party in South Western Colorado, near where the boundaries of this state, Arizona, and New Mexico meet.

The country traversed seems to have been only visited previously, so far as the formation of botanical collections is concerned, by Hayden's U. S. Exploring Expedition about nineteen years ago.

It is extremely mountainous, and intersected by profound chasms, gorges, and precipitous cañons—being consequently very arduous to traverse, the maximum height, perhaps, being not far short of 10,000 feet, but most of the plants to be enumerated were obtained at from 3,000 to 6,000 feet.

The geological formation, for the most part, is mountain limestone.

To the north, the valley of the San Miguel River may be considered the head-quarters of the expedition; and to the south of this, the Uncompahgre region. Long. 108° N., Lat. 38° W.

Under very exceptional difficulties this interesting little collection was gathered by Mr. Lees, the specimens being well selected and well preserved, and partly no doubt owing to the very dry atmosphere, the colours of the flowers have been marvellously retained.

Though not a large collection, it affords a very fair proportion of the characteristic families of the Rocky Mountain area: and, with one or two exceptions, I have been able, with the aid of my own Herbarium, which is rich in representatives of the North American Flora, to name with certainty the specimens collected. Very nearly all of them have a wide range throughout the State of Colorado, extending to the north into Montana, and southwards to New Mexico and Arizona. A few are also inhabitants of the Eastern States; and no less than five also occur in Great Britain. These are *Calystegia sepium*, *Humulus Lupulus*, *Galium boreale*, *Achillea Millefolium*, and *Equisetum arvense.*

No specimens of *Gramina* or *Filices* are represented.

CATALOGUE OF THE PLANTS COLLECTED.

The arrangement followed is that of Dr. Coulter in *Rocky Mountain Botany.*

RANUNCULACEÆ.

Clematis ligusticifolia (Nuttall).
Thalictrum Cornuti (L.).

CAPPARIDACEÆ.

Cleomella Sonoræ (Gray).

Most probably this species, but not in very satisfactory condition.

MALVACEÆ.

Malvastrum coccineum (Gray).

This was submitted to Mr. Edmund G. Baker, F.L.S., who pronounces it a narrow-leaved silvery form of the above. All my own specimens shewed the leaves much broader and less divided.

GERANIACEÆ.

Geranium cæspitosum (James).

A handsome purple flowered form.

RHAMNACEÆ.

Ceanothus Fendleri (Gray).

SAPINDACEÆ.

Negundo aceroides (Mœnch).

In no way differing from the more Eastern form.

ANACARDIACEÆ.

Rhus Toxicodendron (L.).

The well-known Poison Oak or Ivy.

Rhus glabra (L.).

LEGUMINOSÆ.

Thermopsis montana (Nutt).

This is, according to Coulter, *Manual of Rocky Mountain Botany*, p. 52, the *T. fabacea* of Hayden, Rep. 1872. It seems a distinct species, and must be very showy when in flower with its large yellow lupin-shaped flowers.

Lupinus argenteus (Pursh).

A widely-distributed species, with silvery pubescence, and pale blue flowers.

ONAGRACEÆ.

Epilobium paniculatum (Nuttall).

An annual form, with but few flowers, at the summit of almost leafless branches.

Oenothera Missouriensis (Sims).

A handsome large yellow-flowered species.

CORNACEÆ.

Cornus stolonifera (Michx).

This is the *C. pubescens* of King and Hayden's reports.

RUBIACEÆ.

Galium boreale (L.).

In no way differing from the ordinary British form.

COMPOSITÆ.

Gutierrezia Euthamiæ (T. & G.).

Chrysopsis villosa (Nutt.).

Two forms of this variable species, of such wide distribution over the Pacific Slope.

Bigelovia graveolens (Gray).
„ *Douglasii* (Gray).
Two nearly allied species.

Solidago Canadensis (L.).
var.: *procera* (Torr & Gray).
A handsome plant, tall and showy.

Aster Fendleri (Gray).
Aster sp. allied to *Sibiricus L.*, but with narrower leaves.

Erigeron divergens (T. & G.).
Erigeron macranthus (Nuttall).
This last with very handsome many-rayed large purple flowers.

Rudbeckia laciniata (L.).
Wyethia Arizonica (Gray).
A tall Helianthoid species, with bright yellow flowers, oblong lanceolate leaves, and pubescent throughout.

Gymnolomia multiflora (Bentham & Hooker).
With larger flowers than the more ordinary form, but the species is polymorphous. It is the *Heliomeris* of Nuttall.

Helianthus annuus (L.).
Helianthus lenticularis (Douglas).
These two are probably forms of one species, and as such have been united by most modern botanists.

Achillea Millefolium (L.).
More robust than the normal European form.

Artemisia Ludoviciana (Nuttall).
A form of this Protean species—the Sage Brush.

Senecio eremophilus (Richards).
A species endemic in Colorado.

Cnicus ochrocentrus (Gray).

APOCYNACEÆ.
Apocynum androsæmifolium (Linn.).

ASCLEPIADACEÆ.

Asclepiodora decumbens (Gray).

Asclepias speciosa (Torrey).

Two very handsome species.

GENTIANACEÆ.

Gentiana affinis (Grisebach).

Ditto var.

This latter of more compact growth, leaves partially imbricate, and smaller in all its parts.

POLEMONIACEÆ.

Gilia (Collomia) *linearis* (Gray).

" " *aggregata* (Sprengel).

Described by Mr. C. Lees as being extremely beautiful with its scarlet flowers, and growing in the most arid situations imaginable.

BORRAGINACEÆ.

Lithospermum multiflorum (Torrey).

CONVOLVULACEÆ.

Calystegia sepium (R. Br.).

Not apparently differing from British specimens.

SCROPHULARIACEÆ.

Pentstemon azureus (Bentham).

With large blue flowers, and glaucous foliage.

Mimulus Jamesii (Torr. & Gray).

This appears to be the *M. glabratus* (Auct.), a small flowered, rather insignificant, species.

Castilleia linariæfolia (Bentham).

With calyx coloured red-crimson; one of the handsomest of the 'Painted-cups.'

Orthocarpus luteus (Nuttall).

Orthocarpus an. var. præc.? Similar in foliage and growth, but flowers whitish.

Cordylanthus ramosus (Nutt.).

Only a fragment of this well-marked species.

LABIATÆ.

Mentha Canadensis (L.).

Monarda fistulosa (L.).

The typical form of this variable and widely-spread plant.

NYCTAGINEÆ.

Oxybaphus augustifolius (Sweet).

POLYGONACEÆ.

Eriogonum umbellatum (Torrey).

Very fine specimens of this beautiful species.

Eriogonum tenellum (Torrey).

A form.

Eriogonum sp.

A handsome form, with long peduncled leaves, white woolly underneath, and terminal spikes of white and pink flowers.

EUPHORBIACEÆ.

Euphorbia montana (Engelmann).

URTICACEÆ.

Humulus Lupulus (L.).

A very luxuriant form.

LILIACEÆ.

Allium cernuum (Roth.).

Smilacina stellata (Desf.) var. *baccis rubescentibus.*

Evidently this species, which I have gathered abundantly in the North Atlantic States, but the berries are *red.*

Calochortus Gunnisoni (Watson).

Petals pale lilac.

EQUISETACEÆ.

Equisetum arvense (L.).

[*Microscopical and Natural History Section.*]

Ordinary Meeting, October 4th, 1892.

The President of the Section, Mr. R. E. CUNLIFFE, in the Chair.

Mr. J. C. MELVILL exhibited an abnormal specimen of *Ranunculus bullatus* (L.) from the ruins of the Greek Temple at Taormina, just below the Straits of Messina, N.E. coast of Sicily ; found January, 1892, by Miss Louisa Copland and Miss C. Birley. Specimens of the normal condition of the plant were also shown for comparison.

Mr. MELVILL also exhibted a specimen of *Trachelium Cœruleum* (L.) found during the summer in Guernsey by Mr. Buchanan Brown.

Mr. HYDE submitted the following list of plants found growing in the Manchester Infirmary enclosure in 1892 :—

Plantago major.	*Rumex obtusifolius.*
Achillia millefolium.	*Polygonum persicaria.*
„ *ptarmica.*	*Rumex acetosa.*
Tussilago farfara.	„ *acetosella.*
Leontodon taraxacum.	*Poa annua.*
Ranunculus acris.	*Senecia vulgaris.*
Pyrethrum inodorum.	*Trifolium repens.*
Stellaria media.	*Capella Bursa pastoris.*

In addition to *Poa annua* there were two or three other grasses, the flowering being, however, over when they were seen. The following cultivated plants were found growing near the Infirmary :—

Resida odorata.	*Sambucus nigra.*
Saxifraga umbrosa.	*Lignstrum vulgara.*
Primula auricula.	*Polygonum orientale.*
Malcomia Maritima.	*Ulmis sp.*
Tropæolium majus.	*Populus sp.*
Calendula officinalis.	*Cratægus oxyacantha.*
Rhododendron ponticum.	*Fraxinus excelsior.*

Mr. ROGERS exhibited a specimen of *Butimus oblongus* and its eggs; also fossil shells from Fordingham, Lincolnshire.

Mr. HYDE showed a specimen of shale, from Stockport, found in a bed of sand 8 or 10 feet from the surface, covered with rootlets, which, Mr. ROGERS suggested, might be the Mycellium of a fungus.

Mr. CHADWICK exhibited under the microscope living specimens of the Scyphistoma stage in the development of a Scypho-medusa.

[*Microscopical and Natural History Section*].

Ordinary Meeting, November 7th, 1892.

The President of the Section, Mr. R. E. CUNLIFFE, in the Chair.

Mr. G. H. BROADBENT, M.R.C.S., was elected an associate of the Section.

Mr. HYDE exhibited specimens of strayed plants found in the neighbourhood of Manchester.

Linum usitatissimum. *Coriandrum satiorum.*
Hesperis matronalis. *Silans pratensis.*
Pimpinella anisum.

Mr. STIRRUP exhibited specimens of nodules, found in the coal measures, of iron pyrites from the chalk, Crayford, Kent; of flint nodules from Ventnor; and a coral from Ilfracombe.

Mr. ROGERS exhibited a black orange (both inside and out). It was suggested that the colour and condition might be due to a microscopic fungus.

Mr. G. H. BROADBENT, M.R.C.S., &c., exhibited under the microscope a sample of stable manure water containing large numbers of Paramœcia.

Mr. CUNLIFFE exhibited under the microscope specimens of *Polycistina*.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, December 14th, 1892.

The President of the Section, Mr. R. E. CUNLIFFE, in the Chair.

The section adopted the following resolution, proposed by the President :—" That the section notes with regret the death of Sir Richard Owen on the 18th inst., and testifies its sense of the loss which the country has sustained by the death of so distinguished a naturalist."

Mr. HYDE exhibited a specimen of a gall occurring on a Yew tree *(Cecidomyia taxi)*, and stated that in the case of two trees growing side by side, one was covered with the gall and the other was quite free.

Mr. G. H. BROADBENT, M.R.C.S., &c., drew attention to the most recent advances in the microscopic investigation of cancer.

[*Microscopical and Natural History Section*].

Ordinary Meeting, January 16th, 1893.

The President of the Section, Mr. R. E. CUNLIFFE, in the Chair.

Mr. HYDE exhibited parts of a seal, including the head and hind feet, which had been preserved in spirits of wine and corrosive sublimate.

Mr. HYDE also exhibited a branch of the plane tree, illustrating the growth of the buds, the base of the leaf stalk forming a protecting covering to the bud; he stated that he had never noticed this kind of protection in any other tree before.

Mr. CHARLES BAILEY also stated that it was new to him.

Mr. CAMERON exhibited an undescribed fungus gall, found on the roots of one of our native cotton grasses in Cheshire.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, February 13th, 1893.

Mr. P. CAMERON, F.E.S., Vice-President of the Section, in the Chair.

Mr. ROGERS exhibited a number of small species of land shells from South Africa, collected by Mr. J. S. Gibbons, M.B.

Mr. J. COSMO MELVILL, M.A., F.L.S., exhibited a collection of plants formed by Mr. Cardwell Lees in S.W. Colorado.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, March 13th, 1893.

The President of the Section, Mr. R. E. CUNLIFFE, in the Chair.

Mr. JOHN WATSON read a paper "On three Hybrid Silk Moths, hybridised and bred in North America."

Mr. MARK STIRRUP, F.G.S., read a paper on "The Challenger Reports—Deep-sea Deposits: a Review."

Mr. C. H. SCHILL was elected a member of the section.

[*Microscopical and Natural History Section.*]

Annual Meeting, April 10th, 1893.

The President of the Section, Mr. R. E. CUNLIFFE, in the Chair.

Mr. ROGERS exhibited about 30 species of *Achatinellæ* recently collected in Oahu—one of the Hawaiian Islands. The species for the most part were representatives of the group or sub-division, *Achatinellastrum*. He called attention to the similarity of these so-called species to one another, differing principally in colouration and band formulæ.

Mr. ROGERS further remarked that the *Achatinellæ* were confined in their geographical distribution to the Hawaiian Islands; each island has some species peculiar to itself, and each particular ravine has its own particular species; but intermediate forms are found in intermediate spaces. Another peculiarity of a large number of the species is that the spires of the shells are as often found sinistral as dextral.

Mr. G. H. BROADBENT, M.R.C.S., exhibited drainage water from a manure-heap at Ashton, containing infusoria, under the microscope, and gave the results of his observations extending over the last twelve months.

The Annual Report of the Council, and the Treasurer's Financial Statement, were presented and adopted.

The following gentlemen were elected Officers and Council for the ensuing Session:—

President.—R. E. CUNLIFFE.

Vice-Presidents.—ALEX. HODGKINSON, M.B., B.SC.; P. CAMERON, F.E.S.; J. C. MELVILL, M.A., F.L.S.

Treasurer.—MARK STIRRUP, F.G.S.

Secretary.—THEODORE SINGTON.

Council.—CHARLES BAILEY, F.L.S.; JOHN BOYD; G. H. BROADBENT, M.R.C.S., &c.; H. C. CHADWICK; R. D. DARBISHIRE, B.A., F.G.S.; H. HYDE; F. NICHOLSON, F.Z.S.; T. ROGERS.

[*Physical and Mathematical Section*].

Annual Meeting, March 13th, 1893.

JAMES BOTTOMLEY, B.A., D.Sc., F.C.S., President of the Section, in the Chair.

The Treasurer's accounts for the year 1892–93 were presented, and showed :—Balance from last year £2. 15s. 7d., Cash received during current year £2. 0s. 0d., making a total of £4. 15s. 7d., against which were payments during the current year £3. 14s. 2d., leaving a balance of £1. 1s. 5d. in favour of the Section.

It was moved by Mr. WM. THOMSON, F.R.S.Ed., &c., seconded by Mr. T. W. BROWNELL, F.R.A.S., and resolved :—"That the Treasurer's accounts be received and passed."

The following gentlemen were elected officers of the Section for the ensuing year :—

President.—JAS. BOTTOMLEY, B.A., D.Sc., F.C.S.

Vice-Presidents.—J. A. BENNION, M.A., Barrister-at-Law; WM. THOMSON, F.R.S.Ed., F.C.S., F.I.C.

Secretary.—T. W. BROWNELL, F.R.A.S.

Treasurer.—JNO. ANGELL, F.C.S., F.I.C.

The following constitute the Section :—

Members.—JOHN ANGELL, F.C.S., F.I.C.; JAMES BOTTOMLEY, B.A., D.Sc., F.C.S.; T. W. BROWNELL, F.R.A.S.; WM. MATHER, M.P.; WM. THOMSON, F.R.S.Ed., F.C.S., F.I.C. *Associate.*—J. A. BENNION, M.A., Barrister-at-Law.

Annual Report of the Council, April, 1893.

In the Session 1892-3, now closed, 8 new ordinary members have been admitted, 8 have resigned, and 4 have been removed by death. These changes leave the number of ordinary members on the Society's roll on the 31st March, 1893, as 124, against 128 at the corresponding period in 1892. The names of the ordinary members who have died during the session are Dr. Carl Schorlemmer, F.R.S., Dr. J. E. Morgan, the Rev. Canon Lloyd, and Mr. J. S. Crowther. The Society has also lost by death the following honorary members: Alphonse de Candolle, Sir Richard Owen, Dr. A. W. von Hofman, and Dr. Ernest Werner von Siemens. A memoir of Professor Schorlemmer, F.R.S., has been prepared by Professor Harold B. Dixon, F.R.S., and is in course of printing in the Society's *Memoirs.* Memorial notices of the other ordinary and honorary members deceased during the session are either appended to this report, or will be added to it when it is reprinted in the *Memoirs and Proceedings.*

The balance sheets present the details of the receipts and expenditure of the session. The total balance in favour of the Society on the 31st March, 1893, lying in the hands of the Society's bankers, is £136. 8s. 4d. This amount is £34. 12s. 5d. less than the balance at the beginning of the session, and of the funds in hand £106. 17s. 0d. is held for natural history purposes, thus leaving only £29. 11s. 4d. for the general purposes of the Society.

The condition of the Society's premises is such as to require their early renovation, and it is greatly to be desired that the membership should be strengthened, so that the property of the Society may be adequately maintained.

The lack of available funds has to a certain extent prevented much progress being made with the binding of the books in the library, and your Council acknowledges with much pleasure the fact that the Microscopical and Natural History Section has expended the sum of £23. 12s. 0d. in binding natural history works out of grants previously voted by the Society to the Section for natural history purposes, and that they are in the course of printing a catalogue of the natural history works in the Society's library. It may be desirable that the policy of preserving this class of publications should be continued, by binding the whole up to date.

The number of Societies regularly using the building for their meetings is now four, viz. :—

The Manchester Architects' Society.
The Manchester Geological Society.
The Manchester Medical Society.
The Manchester Photographic Society.

The Council recommends the continuance of the system of electing associates of Sections, and the usual resolution authorising the same will be submitted to the annual meeting.

A portrait of Mr. Baxendell, by Mr. Brothers, has been purchased and presented by several members to the Society.

Two meetings of the Society have been held in the afternoon, on February 21st and March 21st. They were the best attended of the meetings of the session, and this result will justify the new Council in repeating the experiment.

During the session an extra volume of the *Memoirs* has been published, consisting of Professor Reynolds's "Memoir" of the late Dr. Joule.

The Council has had under consideration the question of introducing the electric light to replace gas in parts of the Society's house, Mr. Henry Wilde, F.R.S., having generously offered to defray the cost of wiring-up and supplying the necessary fittings.

The Librarian reports that during the past year upwards of 250 volumes have been bound, but there are still many sets of publications that require binding. Every week the library is receiving valuable additions, and it is important that they should be promptly bound. Amongst other works added during the year are the following authors and compilers' presentation copies :—

JAMES E. KEELER. "Elementary Principles governing the Efficiency of Spectroscopes for Astronomical purposes."

A. LIVERSIDGE. "On Some New South Wales and other Minerals."

F. BASHFORTH, B.A. Reprint of "A Description of a Machine for finding the Numerical Roots of Equators."

DARAB DASHIR PESHOTAN SANJANA, B.A. "The Position of Zoroastrian Women in Remote Antiquity."

HENRY WILDE, F.R.S. "On the Origin of Elementary Substances and on some New Relations of their atomic weights."

J. P. THOMPSON. "Practical Suggestions to Travellers."

T. C. JOHNSTON. "Did the Phœnicians Discover America?"

JAMES HENRY. "Æneidea, or Critical, Exegetical, and Æsthetical remarks on the Æneis." Indices.

ALEXANDER IRELAND. "Address on the Moral Influence of Free Libraries."

SHERIDAN LEA. "The Chemical Basis of the Animal Body."

VOLTA BUREAU. "Notes and Observations upon the Education of the Deaf."

J. E. KEELER. "The Spectroscope of the Alleghany Observatory."

Dr. HEINRICH HERTZ. "Untersuchungen ueber die Ausbreitung Der Elektrischen Kraft."

G. DEWALQUE. "Observations sur la Correlation des Diverses Bandes."

S. C. DOTT. M. RAJNA. "Sull' Excursione Diurna della Declinazione Magnetica a Milano."

LOTHAR MEYER. "Grandzüge der Theoretischen Chemie."

In Dr. J. E. MORGAN the Society has lost one of its most distinguished members. Born in 1828, he died after a year's illness in 1892. He was the second son of the Rev. Morgan Morgan, Vicar of Conway, and was educated at Shrewsbury School, and University College, Oxford, where he took his degree in Arts in Classical Honours in 1852, and in Medicine in 1861. In the same year he became a member of the Royal College of Physicians, was elected to its Fellowship in 1868, and to its Council in 1887. The years following his B.A. degree he spent chiefly in the Western Highlands, and here, while reading for ordination, he passed much of his leisure time in visiting the sick-poor in the Islands of the Hebrides, and was thus led to study medicine, with a view to relieving their sufferings He finally determined to follow medicine as a profession, and proceeded to St. Mary's Hospital, London. He afterwards embodied his medical experience in the Highlands, and especially in the remote Island of St. Kilda, in an important paper, published in the *Medico-Chirurgical Review* in 1861, in which he called attention to the prevalence of infantile lockjaw and the rarity of consumption. The former disease he ascribed to the filth of the dwellings, and the immunity to the latter to abundant ventilation and to the presence of peat smoke. He also investigated the singular affection known as the 'boat-cough,' a kind of influenza arising amongst the natives on the arrival of strangers from the mainland. He came to Manchester in 1861, and at once threw himself into undertakings for the amelioration of the condition of the people. He became Physician to the Salford Hospital,and Lecturer on Pathology at the Royal School of Medicine, and in 1863 he took the post of Hon. Sec. to the Manchester and Salford Sanitary Association, and during his term of office he wrote the Weekly, Quarterly, and Annual Reports on the Health of the town. In 1864 he joined a movement, that was started by this

Association, for the formation of a Nurse Training Institution in Manchester and Salford, and he was the means of obtaining from Miss Nightingale six of her best-trained nurses, who were distributed amongst the hospitals of the town, and who at once commenced the training of probationers for the Institution. On Mr. Murray Gladstone's death, Dr. Morgan became Chairman of the Nurse Training Institution, and retained the post for several years. As an outcome of his hospital and sanitary labours, Dr. Morgan published papers on "The Danger of Deterioration of Race," and "Town-Life amongst the Poorest," in which he called attention to the signs of lowered vitality and physical weakness in our town populations, and proved the fact that the constant inflow of fresh country lives into our large towns entirely vitiates all conclusions from their rates of mortality. In 1867 he was elected Hon. Physician to the Manchester Royal Infirmary, and in 1873 he became Professor of Medicine at the Owens College. In 1875 Dr. Morgan wrote a paper on "Medical Education at the Universities," and in 1881 he delivered an address, entitled "The Victoria University—why are there no Medical Degrees?" and there can be no doubt that these essays contributed largely to the early recognition of the Medical Faculty of the Victoria University, and to the speedy granting of the power of conferring Medical Degrees, which had been at first withheld. Dr. Morgan contributed several papers on medical subjects to the *Lancet* and *British Medical Journal*, but his chief work was the "Critical inquiry into the After Health of the men who rowed in the Oxford and Cambridge boat races, from 1829 to 1869, based on the personal experience of the rowers themselves." This book was entitled "University Oars," and was published by Macmillan. It was the result of an enormous amount of labour of correspondence, and it tended to show that hard athletic exercises had no prejudicial influence upon the men engaged in them, but that they lived as long as, if not longer than, those who lived in the same station of life, and who had not been rowing men. Dr. Morgan himself was very fond of all kinds of athletics, and was eminent as an oarsman and as a keen sportsman, but he was especially gifted in his power of literary and oratorical expression. His medical lectures were models of clear and dispassionate discussion of the problems of disease. He was elected a member of the Society on October 29, 1861. A. R.

Mr. JOSEPH STRETCH CROWTHER died at Southport, on March 25th, 1893. He came of a Warwickshire family, from the neighbourhood of Coventry. He was educated partly at Cambridge, and at one time thought of taking holy orders. He was also by way of being a musician, being in St. Alban's Church Choir, and being used to play the organ. As an architect he was articled to Mr. Tattersall, of Manchester. After serving his articles he worked for some time for a firm of mill architects. About 1844 he went into partnership with Mr. J. Bowman, in conjunction with whom he brought out a folio book (1845-50) on "The Churches of the Middle Ages," which still remains one of the standard works on the subject; indeed, it is one of the finest works that the enthusiasm of the Gothic Revival brought forth. In Manchester and the neighbourhood he was best known as an ecclesiastical architect. His first work of any importance was St. Mary's Church, Moss Lane, Hulme, built by Mr. Wilbraham Egerton, of Tatton, and consecrated by Bishop Prince Lee, in November, 1858. In 1874 he was commissioned to design the church of St. Alban's, Waterloo Road, Cheetham, and at a subsequent period the schools of the same church. In 1875 he designed the important new church of St. Mary's, Crumpsall, the original structure of which had been struck by lightning and burnt down. The Bury Parish Church was rebuilt from his designs in 1876. Another work was St. Benedict's, Ardwick, consecrated by Bishop Fraser in March, 1880. In 1885 he restored the chancel and other parts of the Parish Church of Rochdale, and in 1890 he designed the chancel for Littleborough Parish Church. He also restored Kendal Parish Church. Mr. Crowther's principal work, however, was in connection with the Manchester Cathedral, the restoration of which he lived to complete. This restoration was begun some ten years ago. He has left a monograph of the Cathedral nearly completed. Mr. Crowther was a strong supporter of the free and open church movement at a period when it was less powerful than recently. He was elected an ordinary member of the Society on January 25th, 1849; he was, therefore, at the time of his death, one of its oldest members.

The Rev. JULIUS LLOYD, M.A., Rector of St. Philip's, Salford, Canon of Manchester, who died suddenly whilst attending the annual meeting in behalf of the Day Schools Association of Manchester and Salford, held in the Town Hall, Manchester, on May 27th, 1892, was born in London, September 10th, 1830, and educated firstly at Blackheath and then at Berlin, being subsequently entered at Trinity College, Cambridge, where he gained a scholarship in 1851, and was 27th Wrangler in 1852. He took his B.A. degree in that year, was 1st class in the Moral Science Tripos 1853, M.A. 1855, was ordained Deacon in that year, and priest in 1856 by the Bishop of Rochester; was curate of Brentwood, Essex, 1855-57; St. Peter's, Wolverhampton, 1858-62; Trysull, Staffordshire, 1862-66; of St. Peter's, Pimlico, 1866-68; vicar of High Cross, 1868-71; incumbent of St. John, Greenock, 1871-80; rector of St. Ann's, Manchester, 1881-86; Leesfield, Oldham, 1887-91; and St. Philip's, Salford, 1891-2. His published writings were numerous, and include "Life of Sir Philip Sidney," 1862; "Sermons preached at Wolverhampton," 1862; "Sermons preached before the University of Cambridge," 1866; "The Maintenance of the Church of England as an Established Church," Peele Prize Essay, 1874; "Sketches of Church History in Scotland," 1877; "Christian Politics," 1877; and "The North African Church," 1880. He was elected a member of the Society on February 23rd, 1892.

J. C. M.

AUGUST WILHELM VON HOFMANN died May 5th, 1892. For several years he was a resident in this country, having been appointed in 1848 superintendent of the Royal College of Chemistry, London. In 1864 he accepted the Chair of Chemistry at Bonn, and shortly afterwards removed to Berlin. In the Royal Society's catalogue of scientific papers, page after page bears testimony to the extent and interest of his work, both in this country and abroad. His researches were mainly in organic chemistry, wherein he showed himself a worthy successor of Woehler, Liebig, and other early pioneers, who in this branch of science had already made some tracks for the guidance of their successors. His residence in this country was fortunate also in this respect, that his laboratory was the training ground for pupils who caught something of the master's enthusiasm and carried on the good work which he inaugurated; also beyond the sphere of personal influence his writings were of a character to arouse, even in a languid mind, a sense of the growing importance of organic chemistry. In his laboratory much attention was paid to the constitution of the aromatic bodies, and the numerous bases and substitution products derived from them. Many of these compounds, at that time objects of scientific curiosity, are now produced on a large scale, and their names are familiar words in commerce. The eminence of Hofmann marked him out as the fitting recipient of many honors from learned societies. In our own country he was elected a member of the Royal Society in 1851. In 1854 he was awarded a royal medal for his "Memoir on the Molecular Constitution of Organic Bases." He was elected one of the honorary members of the Society on January 23rd, 1866. J. B.

On the 18th of December, 1892, one of the oldest and most eminent of the scientific veterans of our country, Sir RICHARD OWEN, closed his brilliant career at the age of but little under ninety years. He was born at Lancaster on July 20, 1804, and received his early education in the grammar school of the same town. At a later period, selecting medicine for his profession, he matriculated at Edinburgh, but studied practical medicine in the London Hospital of St. Bartholomew's at the time when the "mild Abernethy" of the poet was the ruling spirit of that distinguished school. Whilst there, in 1826, he wrote his first memoir, on the subject of Urinary Calculi, and, on concluding his preparatory studies, he became a Medical Practitioner in London. Previous to this the Government had purchased the fine collection of anatomical preparations made by John Hunter and then in the care of the College of Surgeons, but uncatalogued and unarranged. Like most young practitioners, Owen had abundance of leisure, and at the suggestion of Abernethy he undertook the task of cataloguing the Hunterian collection. In 1830 the newly-established Zoological Society of London held its first meeting, at which Owen read a paper on the "Anatomy of the Ourang Outang," followed two years later by the memoir which first gave a prominent distinction to the young naturalist. For the first time a specimen of the pearly nautilus had fortunately been captured in the eastern seas, which shell, containing its hitherto unknown animal, carefully preserved in alcohol, was placed in

Owen's hands for dissection, and led to the publication of a memoir, the reputation of which associated itself with the name of Owen to the end of his life. The next event that influenced Owen's further career was his introduction to George Cuvier, followed soon afterwards by a visit to Paris. At that time the French Naturalists were in advance of our countrymen in their researches amongst the extinct vertebrate animals. Cuvier had published the first part of his celebrated "Recherches sur les Ossemens Fossiles des Quadrupèdes" as early as 1812. This was succeeded by other parts, the concluding one appearing in 1824. The treasures obtained from the Gypseous quarries of Montmartre, thus, for the first time, made English geologists acquainted with the fact that such extinct forms as the *Palæotherium* and *Anoplotherium* had existed so recently as the period in which the superficial deposits, now known as the Tertiary strata, had been accumulated. To understand the significance of this in its relation to English naturalists we must remember that Buckland's *Reliquiæ Diluvianæ* only appeared in 1826, the discovery of the Kirkdale cave having been made but a short time previously. Under these circumstances we can well understand the impressions which contact with such rich stores of extinct vertebrates would produce upon the receptive mind of our young anatomist. There can be no doubt that this visit stimulated some of the most important of Owen's researches in future years. In December, 1834, Owen being then but 30 years of age, he was elected a fellow of the Royal Society. He was appointed lecturer on Comparative Anatomy at St. Bartholomew's Hospital, and about the same time he married. This last event grew out of those temporary labours at the College of Surgeons which were destined so materially to influence his future life. At the time in question, he was necessarily thrown much into association with the family of

Mr. Clift, who had long been the conservator of the Hunterian Museum, and it was the daughter of that early historian of the *Mastodon* and the *Megatherium* who happily became the companion of so many of Owen's future years. In 1836 he succeeded the celebrated Sir Charles Bell in the Professorship of Anatomy and Physiology, as well as followed the veteran Clift in the curatorship of the College Museum; circumstances which necessarily led to his abandonment of his medical practice. Thus freed from all collateral restraints, he flung himself heartily into the vast succession of researches which became the glory of his future life. Amongst the earliest of these labours were those investigations which culminated in 1840-41 in the publication of his celebrated "Odontography." This treatise described the comparative anatomy, physiological relations, mode of development, and microscopic structure of teeth. It was in many respects an admirable work, though not accurate in some important physiological features. In 1843 he published his lectures on "The Comparative Anatomy of the Invertebrate Animals," followed in 1846 by a similar work on "Fishes." But in the latter year we find him taking a higher flight. Meanwhile, there had arisen in Germany a school of which Lorenz Oken was the prominent representative. Amongst other objects aimed at by that philosophical thinker he sought to discover some laws of unity in the various diversified parts of the vertebrate skeleton. He wanted to know, for example, what the skull was as compared with the vertebrate column from which it appeared to differ so widely. Resting one day whilst hunting in a German forest his eye fell upon the dried skull of a deer that lay in the grass, when the idea suggested itself to his mind that, like the vertebral column, it was merely a chain of modified vertebræ; and, having determined this point, he applied the same theory to the rest of the skeleton. Owen proceeded upon the same hypothesis, when, in

1846, he presented to the British Association a report "On the fundamental type and Homologies of the Vertebrate Skeleton," and he carried out the same dominant idea in 1848 and 1849, when he successively published his two volumes "On the Archetype and Homologies of the Vertebrate Skeleton, with tables of the synonyms of the Vertebral Elements and Bones of the head of Fishes, Reptiles, Birds, Mammals, and Man," followed by a similar treatment of the rest of the skeleton in his volume "On the Nature of Limbs." Ingenious as his arguments and illustrations were it cannot be said that his views have met with general acceptance. From this time onwards Owen poured forth, from year to year, so vast a succession of memoirs, reports, articles for encyclopedias, &c., some on fossils, others on recent objects, but chiefly on vertebrate creatures, as to baffle all comprehension as to how and when one man could accomplish so much detailed work. A mere list of these separate productions would occupy at least a dozen pages of the volume containing this notice. At one time he is devoting his energies to the anatomy of the Monkeys. At another he is preparing a descriptive and illustrated catalogue of the Fossil remains of Mammals and Birds contained in the Museum of the Royal College of Surgeons. Now it is the anatomy of various recent Sloths and of *Mylodon* and the *Megatherium*, two gigantic fossil forms of the same group of semi-arboreal animals. At another time the recent *Armadillos* are engaging his attention along with the South American *Glyptodon*, an enormous extinct creature closely allied to the *Armadillos*. Indeed it is difficult to name any one of the great types of animal forms, recent or extinct, which he has not made the subjects of his minute studies. The great Saurians from the Oolitic and Liassic beds were always favourite objects of his investigations. When the first specimens of the Dinornis, the gigantic Ostrich of New Zealand, came to England he at once gave to them his devoted attention. Chiefly sent, in the first instance, by Walter Mantell to his father, the well-remembered Gideon Mantell, they were laid out in a warmed upper-room of the geologist's house in Chester Square, throughout an entire winter, to facilitate their study by Owen—a facility of which the great anatomist abundantly availed himself. Histories of the British Fossil Reptiles, as well as successive monographs on the Fossil Turtles and their allies from the British Tertiary Deposits, from the Cretaceous Beds and from the Wealden Strata, appeared in the volumes of the Palæontographical Society. The Fossil British Tertiary Serpents and the Crocodiles were dealt with in the same manner. Amidst all these astounding labours the Crown called upon him to undertake a new and serious task. Changes occurring in the management of the British Museum in Bloomsbury, Owen was appointed the supreme Director of the entire department of Natural History. The want of more space in that Institution had long before been felt by the then head of the Zoological Department, the late John Edward Gray. Owen soon also became convinced that such increase of space was absolutely indispensable. He lost no time in urging the Government of the day to make provision for this want, and succeeded in inducing them to bring in a bill authorising the erection of the necessary buildings. The measure however met with violent opposition in Parliament, and Owen personally received considerable Parliamentary abuse for his supposed folly in promoting so extravagant and needless a scheme. Notwithstanding this the measure was carried, and Mr. Alfred Waterhouse, R.A., received instructions to prepare the plans for the present buildings in Cromwell Road. These plans were carried out, and the new Natural History Museum was opened in 1881; the old museum in Bloomsbury being now left in the hands of the antiquarians and the lovers of the plastic arts. Having thus accomplished the great and final task of his life Owen retired from his office of Director in 1883. The great scientific mistake of his life lay in allowing himself to be led into the dreamland of the Physio-philosophy of Oken. Two of the most laborious of his works, his "Homologies of the Vertebrate Skeleton" and "On the Nature of limbs," were devoted to building up a philosophy which is no longer accepted. At the same time he never accepted the philosophy of Darwin, neither did he replace it by any other in the least degree calculated to take its place. He did not refuse to devote time to social labours of a more popular kind. Thus, he was one of the Commissioners for preparing the Great Exhibition of 1851. From 1843 to 1846 he took part in the Commission of Enquiry into the Health of Towns. On other occasions he served on Commissions of Enquiry into the Meat Supply and the Health of the Metropolis, &c. He reported on the drainage and water supply of Lancaster, his native town. The Queen and Prince Albert placed at his disposal an excellent mansion in Kensington, for which, however, at Owen's own request, Sheen Lodge, in Richmond, the home of his future years, was substituted. As we have seen, at an early age he received the fellowship of the Royal Society, followed at a later date by the award both of a Royal and a Copley Medal. The Queen knighted and conferred upon him the Order of the Bath. From Prussia he received the "Ordre pour le Mérite," and Louis Napoleon sent him the Grand Cross of the Legion of Honour. The French Institute made him one of its eight foreign Associates. The King of Italy conferred upon him the order of St. Sulspice and St. Lazare, and the late Emperor of Brazil honoured him after a similar fashion. The names of the scientific societies of Europe who enrolled him amongst their Foreign members was legion. After his long and distinguished life he died on the 20th of last December, and in accordance with his own wishes he now sleeps by the side of his wife in the churchyard of Ham. He was elected an honorary member of the Society on April 30th, 1844.

W. C. W.

By the death of ALPHONSE LOUIS PIERRE PYRAMUS DE CANDOLLE, on the 4th April, 1893, botanical science has lost one of the links which connects this generation with the illustrious Linnæus, Haller, and B. de Jussieu. The father of Alphonse de Candolle was born at Geneva 25 days after the death of Linnæus. He was a descendant of an old Provençal family of Hugenots which had been compelled to expatriate itself at the end of the 16th century, on account of the religious persecutions of the time. Driven out of France the family settled at Geneva, where its descendants have remained to the present day. Alphonse de Candolle was born at Paris, 27th October, 1806, during the temporary residence there of his parents, but circumstances obliged the family to return to Geneva shortly afterwards. Destined for the legal profession, he took his degree of doctor of law at the early age of 23 years, when he wrote for his thesis, on "le droit de grâce." This early legal training was, however, not lost upon him, and it is doubtless owing to the discipline of those early studies that he acquired the capacity for investigating complex problems in a judicial spirit, and it enabled him in his later life to render yeoman's service in public affairs, when he was elected a member of the Representative Council, and afterwards, when he sat upon the Great Council of State. He might have become a great jurist, but yielding to his father's wishes he abandoned the law for botany. Appointed assistant to his father at the Academy, and director of the Botanical Gardens in Geneva in 1831, he succeeded him in these offices in 1835, throwing himself into the full current of the parental studies. The elder de Candolle had projected an extensive work which aimed at describing the vegetation of the world, but it was on too vast a scale to ensure its completion within the life-time of its author; after two volumes had been issued, one in 1817 and the other in 1821, the 'Systema naturale regni vegetabilis' was not continued further. But it was the forerunner of the work which will be the best monument of the three generations of de Candolles, father, son, and son's son, viz., the 'Prodromus systematis naturalis vegetabilis.' The father had published seven volumes of the 'Prodromus' prior to his death in September, 1841, and the son's name first appears on the title page of Volume VIII., which he dedicated to his father's memory and published in 1844. Eight other volumes successively appeared, the 17th volume bringing the first series to a close, 16th October, 1873. These seventeen volumes are concerned with the description and geographical distribution of dicotyledonous plants, each part issued in systematic order; but Alphonse de Candolle, in conjunction with one of his two sons, viz., Casimir, projected their 'Suites au Prodromus' with main reference to monocotyledons, though not excluding dicotyledons; the first volume was published in June, 1878, and the seventh in July, 1891, but, unlike the 'Prodromus' proper, its separate volumes do not occur in systematic sequence, and its international character is exemplified by the languages in which it is being written. Though circumstances were conspiring to make him a lawyer, inclination and parental wishes conspired to make him a botanist, and one who was to become one of the great systematists of the age. In his 17th year he came under the sway of the writings of von Humboldt, and this savant's conception of animated nature started him upon a line of investigation which he never afterwards abandoned. But for family affairs he would have found himself in the New World, traversing the regions which Humboldt had described. The causes which have controlled the distribution of vegetable life upon the earth's surface in past, and existing, eras, constituted the problem to the solution of which he gave the best powers of his life, and in due time the fruit of his studies appeared in the two volumes of 'Géographie botanique raisonnée' in 1855. Notwithstanding his numerous and varied writings in other departments of botany, there seems to run in them an inner thread which connects them all with his great theme of geographical distribution, it may be through philology, or anatomy, or chemistry. In this light, his remarkable work 'Origine des plantes cultivées,' published in 1883, is merely a development of one branch of phytogeography already touched upon in his 'Géographie botanique,' in which latter work the story of the cultivated vine forms a classical portion. Even his great work as a systematist is controlled by the relations which he saw underlying the modifications of the organs of plants through topographical limitations. Alphonse de Candolle has exercised remarkable powers over his contemporaries in regard to the vexed questions involved in botanical nomenclature. He had prepared the way for this by the publication of a philosophy of botany under the modest title of 'La phytographie, ou l'art de décrire les végétaux considérés sous différents points de vue.' No other botanist of his age would have been able to command the unanimity of his colleagues of all nationalities, assembled at the International Congress of Botany, held at Paris on the 16th August, 1867, in accepting the code of 68 rules which he then submitted, and which code is still the acknowledged foundation for guidance in this most thorny and complicated subject. If the glory of the father had been to consolidate the bases of the natural system of classification, the glory of the son has been to evolve the laws of nomenclature in the application of the natural system to the denomination of plants. The de Candolles possessed an immense herbarium which the traditions of the family imposed being made of a quasi-public character. The father left to the son at least 70,000 species of plants, the whole of which have been used in the preparation of the 'Prodromus;' the son, just deceased, has added immense collections to the same herbarium, and it doubtless decends to the third generation with the same facilities for consulting it as have been enjoyed by botanists of every country for more than half a century, in Geneva, the city of great herbaria. Alphonse de Candolle was a voluminous writer, as he is the author of at least 250 separate publications and articles in scientific journals. He was elected an honorary member of the Society on April 26th, 1892. C. B.

Ernest Werner von Siemens was born at Leuthe, Hanover, in 1816. He was the eldest of seven brothers, one of whom, Sir William Siemens, was well known in this country. Dr. Siemens, at the age of 18, joined the Prussian Artillery, and gained the rank of lieutenant three years later. A graphic description of his early career is given in a short volume of autobiography which appeared a few weeks before his death. While still holding his military appointment, he became the inventor of a process of electro-gilding and of an automatic recording telegraph His attention was then drawn to the advantages of placing, if possible, all electric leads under the surface of the ground. The difficulty, which had to be overcome, was the finding of a suitable covering to the wire, which should be insulating and at the same time resist corrosion. Although unsuccessful at the time, the experiments performed, and the researches undertaken on the coating of wires with gutta-percha, were ultimately found to be of great value. Shortly afterwards Werner Siemens retired from the army, and gave up his time to the working out of a series of inventions, which have made his name, and that of his brothers, celebrated in all countries. All branches of electro-technics show the fruits of his inventive genius; it is only necessary here to allude to his improvements in the self-exciting dynamo machine and the introduction of the armature which bears the name of Siemens. In 1886 Werner Siemens presented a sum of £25,000 to the German Government for the foundation of a national scientific and technical institution. Although in existence only for a few years, this institution has already done great service to pure and applied science. His autobiography, which has already been alluded to, forms an interesting and fascinating volume, giving a graphic account of his successes and failures. Amongst the many incidents recorded in that volume, the following is characteristic. Siemens had taken a leading part in extending the telegraph in many parts of Germany. A young lady wrote to him a pathetic letter, in which she explained that he was going to ruin her husband, who had established a pigeon post between Cologne and Brussels. Siemens answered that her husband had better roast his pigeons, but promised his assistance if they would go to London to establish a news agency. The husband followed the advice; his name was Reuter, and Reuter's news agency is a proof that Siemen's suggestion was not a bad one. Dr. Werner von Siemens died on December 6th, 1892. His lectures and papers are published under the title "Gesammelte Abhandlungen u. Vorträge." He was elected an honorary member of the Society on April 30th, 1889.

A. S.

MANCHESTER LITERARY AND

Charles Bailey, Treasurer, in Account with the Society,

Dr. *Statement of the Accounts*

1893—March 31st:	1892-3. £ s. d.	£ s. d.	1891-2. £ s. d.	£ s. d
To Cash in hand, 1st April, 1892		171 0 9		353 0
To Members' Contributions:—				
Admission Fees:—1891-92, 4 at £2. 2s. 0d...	8 8 0			
,, 1892-93, 5 ,, ...	10 10 0			
Subscriptions:— 1889-90, 3 ,, ...	6 6 0			
,, 1890-91, 4 ,, ...	8 8 0			
,, 1891-92, 22 ,, ...	46 4 0			
,, 1892-93, 92½ ,, ...	194 5 0			
,, 1893-94, 3 ,, ...	6 6 0			
		280 7 0		294 0
To Library Subscriptions:—				
One Natural History Associate, 1892-3, at 10s.		0 10 0		0 10
To Contributions from Sections:—				
Microscopical and Natural History Section, 1892-93 ..	5 5 0		10 10 0	
Physical and Mathematical Section 1891-92 ..	2 2 0		2 2 0	
		7 7 0		12 12 0
To Use of the Society's Rooms:—				
Mr. G. Bridgford, 25—26th January, 1893	2 2 0		0 0 0	
Manchester Architects' Society to 31st Dec., 1892	30 0 0		0 0 0	
Manchester Geological Society to 31st March, 1893 ..	30 0 0		60 0 0	
Manchester Medical Society to 30th September, 1892 ..	25 0 0		25 0 0	
Manchester Photographic Society to 30th Sept., 1892 ..	25 5 0		30 0 0	
Manchester Scientific Students' Asso. to Nov., 1891 ..	0 0 0		6 0 0	
		112 7 0		121 0 0
To Sale of the Society's Publications, 1892-93		9 18 8		2 6 5
To Natural History Fund, 1892-3:—				
Dividends on £1225, Great Western Railway Co. Stock..		59 14 4		59 14 4
To Bank Interest, less Bank Postages, 1892-93		1 12 5		4 12 10
To Donation: Rev. Thomas P. Kirkman, M.A.		0 0 0		5 0 0
,, Mr. Wm. Brockbank, F.G.S., &c.		0 0 0		10 0 0
		£642 17 2		£862 15 10

1893.—April 1. To Cash in Williams, Deacon, Manchester and Salford Bank, Limited.. .. £136 8 4

PHILOSOPHICAL SOCIETY.

from 1st April, 1892, to 31st March, 1893, with a Comparative for the Session 1891-2.

Cr.

1893—March 31st:—	1892-93. £ s. d.	£ s. d.	1891-92. £ s. d.	£ s d
By Charges on Property:—				
Chief Rent (Income Tax deducted)	12 12 0		12 12 0	
Income Tax on Chief Rent	0 6 3		0 6 3	
Insurance against Fire	13 17 6		13 17 6	
Repairs to Building, Gas, and Furniture	14 4 1		21 17 1	
New Book-shelves in Cloak Room	0 0 0		5 12 0	
		40 19 10		54 4 10
By House Expenditure:—				
Coal, Gas, Water, Wood, &c.	49 2 3		34 12 2	
Tea, Coffee, &c., at Meetings	12 5 11		11 7 8	
Cleaning, Cleaning Carpets, Sweeping Chimneys, &c. ..	4 3 3		12 15 11	
		65 11 5		58 15 9
By Administrative Charges:—				
Clerk and Housekeeper	67 4 0		62 8 0	
Postages and Carriage of Parcels	33 17 6		28 18 8	
Stationery, Receipts, and Engrossing	3 12 1		2 17 9	
Printing Circulars, Reports, and List of Members	16 16 0		21 4 6	
Distributing 'Memoirs,' Address Wrappers, &c.	6 14 9		7 17 9	
		128 4 4		123 6 8
By Publishing:—				
Honorarium for editing the Society's publications, 1892-3..	50 0 0		50 0 0	
Printing 'Memoirs and Proceedings'	112 1 0		225 1 9	
Binding 'Memoirs and Proceedings'	0 0 0		19 10 0	
Wood Engraving and Lithography	22 4 0		24 12 7	
		184 5 0		319 4 4
By Library:—				
Binding Books in Library	5 12 9		1 13 0	
Books and Periodicals	28 2 11		30 14 8	
Preparing New Catalogue and re-arranging Library ..	10 0 0		40 0 0	
Assistant in Library	8 0 0		15 0 0	
Catalogue Boxes, Slips, &c.	0 0 0		2 3 0	
Palæontographical Society for the year 1893	1 1 0		2 2 0	
Ray Society for the year 1893	1 1 0		2 2 0	
Zoological Record, Vol. 28 for 1891	1 0 0		1 0 0	
		54 17 8		94 14 8
By Natural History Fund:—				
Natural History Books and Periodicals	19 4 7		18 6 7	
Grant to Microscopical and Natural History Section ..	0 0 0		0 0 0	
Plates for Natural History Papers in 'Memoirs'	13 6 0		23 2 3	
		32 10 7		41 8 10
By Balance 31st March, 1893		136 8 4		171 0 9
		£642 17 2		£862 15 10

NOTE.—The Accounts (of which the above is a summary) have been audited and found correct, April 17th, 1893, by Mr. Francis Jones, F.R.S.E., F.C.S., and Mr. Harry Grimshaw, F.C.S.

Summary Balance Sheet, Session 1892-93.

		£ s. d.	£ s. d.
General Account :—			
Balance against this Account, 1st April, 1892		86 2 6	
Expenditure during the Session, 1892-93 :—			
Charges on Property	£40 19 10		
House Expenditure	65 11 5		
Administrative Charges	128 4 4		
Publishing	184 5 0		
Library	54 17 8		
		473 18 3	
			560 0 9
Receipts during the Session, 1892-93 :—			
Subscriptions, Admission Fees, Sections, &c.	£288 4 0		
Use of the Society's rooms	112 7 0		
Sale of the Society's publications	9 18 8		
Bank Interest	1 12 5		
			412 2 1
Balance against this Account, 31st March, 1893			147 18 8
Compounder's Fund :—			
Balance in favour of this Account, 1st April, 1892		177 10 0	
Balance in favour of this Account, 31st March, 1893			177 10 0
Natural History Fund :—			
Balance in favour of this Account, 1st April, 1892	£79 13 3		
Dividends on Great Western Railway Co.'s Stock during the Session 1892-93	59 14 4		
		139 7 7	
Expenditure during the Session 1892-93 :—			
Natural History Books and Periodicals	£19 4 7		
Drawing, engraving, and printing plates on Natural History subjects	13 6 0		
		32 10 7	
Balance in favour of this Account, 31st March, 1893			106 17 0
			284 7 0
Less balance, as above, against the General Account			147 18 8
Cash in Williams, Deacon, and Manchester and Salford Bank, Limited, 31st March, 1893			£136 8 4

Annual Report of the Council of the Microscopical and Natural History Section.

During the Session 1892-3 the usual number of sectional meetings have been held, at which papers have been read and communications made by:—Messrs. CAMERON, CHADWICK, CUNLIFFE, HYDE, MELVILL, ROGERS, STIRRUP, and BROADBENT. By invitation of Mr. MELVILL, Mr. JOHN WATSON and Mr. CARDWELL LEES, visitors, read interesting papers before the section. Manuscripts of the more important papers and communications submitted to the Section have been sent to the Honorary Secretaries of the Parent Society.

The attendance of members and associates has been about the average. During the session one member has been elected, Mr. C. H. SCHILL, and one associate, Mr. G. H. BROADBENT, M.R.C.S., &c. The following have resigned:—Mr. BLACKBURN, Mr. COLLETT, and Mr. EARL. Mr. HENN has removed to Australia. The Section now consists of 21 members and 16 associates.

During the session the library sub-Committee appointed at the last Annual Meeting has been engaged on the preparation of the new catalogue of Natural History books, which is now in type and will probably be completed during the summer.

The Council have decided to make the following additions to the library:—The *Irish Naturalist*, to be purchased from the commencement, and *The Conchologist*.

The following is a list of members and associates of the Section:—

Members :—J. J. Ashworth, Charles Bailey, F.L.S., John Boyd, Henry Brogden, Alfred Brown, M.D., Samuel Cottam, F.R.A.S., Edward Coward, R. Ellis Cunliffe, R. D. Darbishire, B.A., F.G.S., Hastings C. Dent, F.L.S., William King Dean, F. J. Faraday, F.L.S., Edward Halkyard, Charles James Heywood, Alexander Hodgkinson, B.Sc., M.B., Sir Henry Hoyle Howorth, F.S.A., M.P., C. H. Hurst, A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S., J. Cosmo Melvill, M.A., F.L.S., Francis Nicholson, F.Z.S., J. F. W. Tatham, M.A., M.D., C. H. Schill.

Associates :—E. J. Bles, M.B., G. H. Broadbent, M.R.C.S., &c., Peter Cameron, F.E.S., H. C. Chadwick, Peter Cunliffe, John Ray Hardy, Henry Hyde, Leslie Jones, M.D., H. L. Knoop, Thomas Rogers, W. R. Scowcroft, Theodore Sington, George Nash Skipp, Mark Stirrup, F.G.S., Edward Ward, F.R.M.S., R. Wheeler.

Mark Stirrup, Treasurer, in account with the Microscopical and Natural History Section of the Manchester Literary and Philosophical Society.

Dr. *Session 1892-93.* **Cr.**

		£	s.	d.
1892.				
April 7	To Balance in Bank and Hands of Treasurer	102	4	3
Dec. 20	,, Bank Interest	1	0	4
	,, Subscriptions and arrears from April 5th, 1892, to April 5th, 1893	15	10	0
		£118	14	7
	To Balance to Credit of Section	69	8	5

		£	s.	d.
1892.				
April.	By John Heywood, Photo Album	1	8	0
Oct. 1.	,, J. Walker, Cataloguing Nat. Hist. Books	2	2	0
Dec. 6.	,, Bank Cheque Book	0	2	1
,, 7.	,, West, Newman, and Co., "Journal of Botany," 1892	0	12	0
1893.				
Feb. 9.	,, Chas. Simms and Co., Circulars, April, 1892	0	5	6
,, 10.	,, David Douglas, "Annals of Scot. Nat. Hist.," 1893	0	7	6
,, 20.	,, B. O'Connor, Printing Cards and Circulars	2	7	6
,, ,,	,, Eason and Son, "Irish Naturalist," 1892—93	0	8	6
,, 24.	,, J. E. Cornish, "Naturalist," April to December	0	4	6
,, ,,	,, W. E. Collinge, "The Conchologist," for 1893	0	4	4
Mar. 13.	,, Parent Society, Sectional Subscription	5	5	0
April 5.	,, C. Hargreaves— Teas 2 12 0; Postages, &c. 1 5 3	3	17	3
,, ,,	,, Williams & Norgate, Fauna and Flora d. Golfes von Neapel, Monograph XIX., Years X.—XII.	8	5	0
,, ,,	,, Palmer, Howe, and Co., Binding Nat. Hist. Books	23	12	0
,, ,,	,, Mark Stirrup, Postages, 5 Sessions	0	5	0
,, 10.	,, Balance in Manchester and Salford Bank (St. Anne's Branch)	69	8	5
		£118	14	7

Examined and found correct,

(Signed) HENRY HYDE.
G. H. BROADBENT.

April 10th, 1893.

The Microscopical and Natural History Section of the Manchester Literary and Philosophical Society in account with the Parent Society for Grant for Books from Natural His'ory Fund.

Dr. *From April 7th, 1892, to April 10th, 1893.* **Cr**

		£	s.	d.
1892.				
April 7.	To Balance of Grant unexpended	25	6	1
	,, Balance	8	12	11
		£33	19	0

		£	s.	d.
1892.				
Oct. 1.	By Cataloguing Natural History Books	2	2	0
1893.				
April 5.	,, Fauna and Flora d. Golfes v. Neapel. Vols. X.—XII.	8	5	0
,, ,,	,, Binding Natural History Books	23	12	0
		£33	19	0
	By Balance due to Section	8	12	11

THE COUNCIL AND MEMBERS.

APRIL 18TH, 1893.

President.

ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S.

Vice-Presidents.

EDWARD SCHUNCK, PH.D., F.R.S., F.C.S.
OSBORNE REYNOLDS, M.A., LL.D., F.R.S.
JAMES BOTTOMLEY, B.A., D.Sc., F.C.S.
JAMES COSMO MELVILL, M.A., F.L.S.

Secretaries.

FREDERICK JAMES FARADAY, F.L.S., F.S.S.
REGINALD F. GWYTHER, M.A.

Treasurer.

CHARLES BAILEY, F.L.S.

Librarian.

FRANCIS NICHOLSON, F.Z.S.

Of the Council.

JOHN BOYD.
HAROLD B. DIXON, M.A., F.R.S.
ALEXANDER HODGKINSON, M.B., B.Sc.
J. W. F. TATHAM, B.A., M.D.
Alderman JOSEPH THOMPSON.
FRANCIS JONES, F.R.S.Ed., F.C.S.

Honorary Members.

Date of Election.	
1892, April 26.	Abney, Capt. W. de, R.E., F.R.S. *S. Kensington.*
1892, April 26.	Amagat, E. F. 34, *Rue St. Lambert, Paris.*
1887, April 19.	Armstrong, Wm. George, Lord, C.B., D.C.L., LL.D. *Newcastle-on-Tyne.*
1892, April 26.	Ascherson, Paul F. Aug. *Berlin.*
1892, April 26.	Baeyer, Adolf von, Professor of Chemistry. 1, *Arcisstrasse, Munich.*
1886, Feb. 9.	Baker, Sir Benjamin, LL.D., M. Inst. C.E. 2, *Queen's Square Place, Westminster, S.W.*
1886, Feb. 9.	Baker, John Gilbert, F.R.S. *Kew.*
1886, Feb. 9.	Berthelot, Prof. Marcellin, For. Mem. R.S., Membre de l'Institut. *Paris.*
1892, April 26.	Boltzmann, Ludwig, Professor of Physics. *Munich.*
1892, April 26.	Brioschi, Francesco. 4, *Place Cavour, Milan.*
1886, Feb. 9.	Buchan Alexander, F.R.S.E. 72, *Northumberland Street, Edinburgh.*
1860, April 17.	Bunsen, Robert Wilhelm, Ph.D., For. Mem. R.S., Prof. of Chemistry at the Univ. of Heidelberg. *Heidelberg.*
1888, April 17.	Cannizzaro, S., Prof. of Chemistry. *University of Rome.*
1889, April 30.	Carruthers, William, F.R.S. Keeper of Botanical Dept., British Museum.
1859, Jan. 25.	Cayley, Arthur, M.A., LL.D., D.C.L., V.P.R.A.S., F.C.P.S., Sadlerian Prof. of Pure Maths. in the Univ. of Cambridge, Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Garden House, Cambridge.*
1886, Oct. 30.	Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Prof. of Natural Philosophy, Oxford. *New Museum, Oxford.*
1899, April 30.	Cohn, Ferdinand, Professor of Botany. 26, *Schweidnitzer Stadtgraben, Breslau.*
1887, April 19.	Cornu, Professor Alfred, For. Mem. R.S., Membre de l'Institut. *Ecole Polytechnique, Paris.*
1892, April 26.	Curtius, Theodor, Professor of Chemistry. *Kiel.*
1892, April 26.	Darboux, Gaston, Professor to the Faculty of Sciences. 36, *Rue Gay Lussac, Paris.*
1886, Feb. 9.	Dawson, Sir John William, C.M.G., M.A., F.R.S., LL.D., F.G.S. *McGill College, Montreal.*
1888, April 17.	Dewalque, Gustave, Professor of Geology, Commandeur de l'Ordre de Leopold. *University of Liège.*
1392, April 26.	Dohrn, Dr. Anton, Zoological Station. *Naples.*
1892, April 26.	Dyer, W. T. Thiselton, F.R.S., Director, Botanical Gardens. *Kew.*
1892, April 26.	Edison, Thomas Alva. *Orange, N.J.*

Date of Election.

1886, April 30. Farlow, W. G., Professor of Botany. *Harvard College, Cambridge, Mass, U.S.A.*

1889, April 30. Flower, Sir William Henry, C.B., LL.D., F.R.S. Director of Nat. Hist. Dept., British Museum.

1889, April 30. Foster, Michael, M.A., M.D., LL.D., Sec. R.S., Professor of Physiology. *Trinity College, Cambridge.*

1860, Mar. 9. Frankland, Edward, Ph.D., M.D., LL.D., D.C.L., V.P.C.S., F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *The Yews, Reigate Hill, Reigate.*

1892, April 26. Friedel, Ch., Professor to the Faculty of Sciences. 9, *Rue Michelet, Paris.*

1892, April 26. Fürbringer, Prof. Max. *Jena.*

1892, April 26. Gegenbauer, Carl, Professor of Anatomy. *Heidelberg.*

1892, April 26. Gibbs, Professor W. J. *West Nyack, N. Y.*

1886, Feb. 9. Helmholtz, Geheimrath Herman von, LL.D., For. Mem. R.S. Präsident der Physikalisch-technischen Reichsanstalt. *Berlin.*

1889, April 30. Hertz, H., Professor of Physics. *Bonn.*

1892, April 26. Hermite, Ch. 2, *Rue de la Sorbonne, Paris.*

1892, April 26. Hill, W. G. *Washington.*

1848, Jan. 25. Hind, John Russell, LL.D., F.R.S., F.R.A.S., Superintendent of the Nautical Almanac. Cor. Mem. Inst. Fr. (Acad. Sci.). 3, *Cambridge Park Gardens, Twickenham.*

1881, April 17. Hittorf, Johann Wilhelm, Professor of Physics. *Polytechnicum, Münster.*

1892, April 26. Hoff, J. Van't, Professor of Chemistry. *Amsterdam.*

1892, April 26. Hooker, Sir Joseph D., F.R.S. *Sunningdale.*

1869, Jan. 12. Huggins, William. LL.D., D.C.L., F.R.S. F.R.A.S., Cor. Mem. Inst. Fr. (Acad. Sci.) 90, *Upper Tulse Hill, Brixton, London, S. W.*

1872. April 30. Huxley, Thomas Henry, M.D., Ph.D., LL.D., D.C.L., P.P.R.S., Hon. Prof. of Biology in Royal School of Science Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Hodeslea, Staveley Road, Eastbourne.*

1851, April 22. Kelvin, Lord, M.A., D.C.L., LL.D., F.R.S.E., P.R.S., Prof. of Nat. Phil. in Univ. of Glasgow. For Assoc. Inst. Fr. (Acad. Sci.), 2, *College, Glasgow.*

1852, Oct. 16. Kirkman, Rev. Thomas Penyngton, M.A., F.R.S., *Fernroyd, Bowdon.*

1892, April 26. Klein, Professor Felix. 3, *Wilhelm Weber Strasse, Göttingen.*

1892, April 26. Kundt, August, Professor of Physics. 16, *Neue Wilhelm Strasse, Berlin.*

1892, April 26. Ladenburg, A., Professor of Chemistry. 3, *Kaiser Wilhelm Strasse, Breslau.*

Date of Election.

1887, April 19. Langley, Prof. S. P. *Smithsonian Institution, Washington, U.S.*

1892, April 26. Liebermann, C., Professor of Chemistry. *29, Matthai-Kirche Strasse, Berlin.*

1887, April 19. Lockyer, Norman, F.R.S., Corr. Mem. Inst. Fr. (Acad. Sci.) *Science School, Kensington.*

1889, April 30. Lubbock, Sir John, Bart., M.P., D.C.L., LLD., F.R.S. 15, *Lombard Street, E.C.*

1892. April 26. Ludwig, Carl, Professor of Physiology. 16, *Liebig Strasse, Leipsic.*

1892, April 26. Marignac, J. C. de *Geneva.*

1892, April 26. Marshall, Alfred, Professor of Political Economy. *Balliol Croft, Madingley Road, Cambridge.*

1892, April 26. Mascart, E., Professor at the Collége de France. 176, *Rue de l'Université, Paris.*

1889, April 30. Mendeléeff, D,, Professor of Chemistry. *St. Petersburg.*

1889, April 30. Meyer, Lothar, Professor of Chemistry. *Tübingen.*

1892, April 26. Meyer, Victor, Professor of Chemistry. 55, *Plöck Strasse, Heidelberg.*

1892, April 26. Moissan, H., Professor at the École Supérieure de Pharmacie. 7, *Rue Vauquelin, Paris.*

1887, April 19. Newcomb, Prof. Simon, For. Mem. R.S. *Johns Hopkins University, Baltimore, U.S.*

1866, Feb. 9. Pasteur, Louis, For. Mem. R.S., Membre de l'Institut. *Paris.*

1892, April 26. Perkin, W. H., F.R.S. *The Chestnuts, Sudbury, Harrow.*

1851, April 29. Playfair, Rt. Hon. Sir Lyon, K.C.B., LL.D., Ph.D., F.R.S., F.G.S., M.P., V.P.C.S., &c. 68, *Onslow Gardens, London. S.W.*

1892, April 26. Poincaré H., Professor to the Faculty of Sciences. 63, *Rue Claude Bernard, Paris.*

1866, Jan. 23. Prestwich, Joseph, F.R.S., F.G.S., Corr. Mem. Inst. Fr. (Acad. Sci.) *Shoreham, near Sevenoaks.*

1892, April 26. Quincke, G. H., Professor of Physics. 60, *Haupt Strasse, Heidelberg.*

1886, Jan. 23. Ramsay, Sir Andrew Crombie, LL.D., F.R.S., F.G.S., 15, *Cromwell Crescent, South Kensington, London.*

1892, April 26. Raoult, F., Professor to the Faculty of Sciences. 2, *Rue des Alpes, Grenoble.*

1849, Jan. 23. Rawson, Robert, F.R.A.S. *Havant, Hants.*

1866, Feb. 9. Rayleigh, John William Strutt, Lord, M.A., D.C.L., (Oxon), LL.D. (Univ. McGill), Sec. R.S., F.R.A.S. *Tirling Place, Witham, Essex.*

1892, April 26. Reymond, Emil du Bois, Professor of Physiology. 15 *Neue Wilhelm Strasse, Berlin.*

1889, April 30. Résal, Professor Henri, Membre de l'Institut. *Ecole Polytechnique, Paris.*

Date of Election.	
1889, April 30.	Roscher, Dr. Wilhelm, K. Geheimer Rath, and Professor of Political Economy, *Leipsic.*
1889, April 30.	Routh, Edward John, Sc.D., F.R.S. *Newnham Cottage, Cambridge.*
1872, April 30.	Sachs, Julius von, Ph.D. *Wurzburg*
1889, April 30.	Salmon, Revd. George, D.D., D.C.L., LL.D., F.R.S., Regius Professor of Divinity. *Provost's House, Trinity College, Dublin.*
1892, April 26.	Salvin, Osbert, F.R.S. *Haslemere.*
1892, April 26.	Saporta, the Marquis de. *Aix-en-Provence, Bouches du Rhône.*
1892, April 26.	Sharpe, R. Bowdler. *British Museum, Cromwell Road, S. W.*
1892, April 26.	Solms, H. Graf zu, Professor of Botany. *Strasburg.*
1869, Dec. 14.	Sorby, Henry Clifton, LL.D., F.R.S, F.G.S, &c. *Broomfield, Sheffield.*
1851, April 29.	Stokes, Sir George Gabriel, Bart., M.A., LL.D., D.C.L., P.P.R.S.; Lucasian Professor of Mathem. Univ. Cambridge, F.C.P.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Lensfield Cottage, Cambridge.*
1886, Feb. 9.	Strasburger, Professor. *Bonn.*
1861, Jan. 22.	Sylvester, James Joseph, M.A., D.C.L., LL.D., F.R.S., Savilian Prof. of Geom. in the Univ. of Oxford, Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *New College, Oxford.*
1868, April 28.	Tait, Peter Guthrie, M.A., F.R.S.E., &c., Professor of Natural Philosophy, Edinburgh. 38, *George Square, Edinburgh.*
1872, April 30.	Trécul, A., Member of the Institute of France. *Paris.*
1886, Feb. 9.	Tylor, Edward Burnett, F.R.S., D.C.L. (Oxon), LL.D. (St. And. and McGill Colls.), Keeper of University Museum. *Oxford.*
1868, April 28.	Tyndall, John, LL.D., M.D., D.C.L., Ph.D., F.R.S., F.C.S. *Hind Head House, Haslemere, London, W.*
1892, April 26.	Walker, General Francis A., Professor of Political Economy. 237, *Beacon Street, Boston, U.S.A.*
1892, April 26.	Wiedemann, G., Prof. of Physics. 35, *Thalstrasse, Leipsic.*
1889, April 30.	Williamson, Alexander William, Ph.D., LL.D. For. Sec. R.S., Corr. Mem. Inst. Fr. (Acad. Sci.). *High Pitfold, Shottermill, Haslemere.*
1886, Feb. 7.	Williamson, W. C., LL.D., F.R.S., 43, *Elms Road, Clapham Common, London.*
1886, Feb. 9.	Young, Prof. C. A. *Princeton College, N.J., U.S.*
1888, April 17.	Zirkel, Ferdinand, Professor of Mineralogy. *University of Leipsic.*

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Date of Election.	
1860, April 17.	Ainsworth, Thomas. *Cleator Mills, near Egremont, Whitehaven*
1870, March 8.	Cockle, The Hon. Sir James, M.A., F.R.S., F.R.A.S., F.C.P.S. 12, *St. Stephen's Road, Bayswater, London.*
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1859, Jan. 25.	Le Jolis, Auguste-François, Ph.D. Archiviste perpétuel and late president of the Soc. Nat. Sc. Cherbourg, &c. *Cherbourg.*
1857, Jan. 27.	Lowe, Edward Joseph, F.R.S., F.R.A.S., F.G.S., Mem. Brit. Met. Soc., &c. *Shirenewton Hall, near Chepstow*
1869, Feb. 5.	Schönfield, Edward, Ph.D., Director of the Mannheim Observatory.

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Date of Election.

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1870, Dec. 13. Angell, John, F.C.S., F.I.C. 6, *Beacons Field, Derby Road, Fallowfield, Manchester.*
1861, Jan. 22. Anson, Rev. George Henry Greville, M.A., *Birch Rectory Rusholme.*
1885, Nov. 17. Armstrong, Thomas. *Brookfield, Urmston; Deansgate.*
1837. Aug. 11. Ashton, Thomas. 36, *Charlotte Street.*
1881, Nov. 1. Ashton, Thomas Gair, M.A. 36, *Charlotte Street.*
1887, Nov. 16. Ashworth, J. Jackson. 39, *Spring Gardens, City.*

1865, Nov. 15. Bailey, Charles, F.L.S. *Ashfield, College Road, Whalley Range, Manchester.*
1888, Nov. 13. Bailey, G. H., D.Sc., Ph.D. *The Owens College.*
1888, Feb. 7. Bailey, Alderman W. H. *Summerfield, Eccles New Road.*
1868, Dec. 15. Bickham, Spencer H. *Underdown, Ledbury.*
1861, Jan. 22. Bottomley, James, D.Sc., B.A., F.C.S., 220, *Lower Broughton Road.*
1875, Nov. 16. Boyd, John, F.Z.S. *Barton House, Didsbury Park, Didsbury.*
1889, Oct. 15. Bradley, Nathaniel. *Sunnyside, Whalley Range.*
1855, April 17. Brockbank, William, F.G.S., F.L.S., *Chapel Walks.*
1861, April 2. Brogden, Henry, F.G.S., *Hale Lodge, Altrincham.*
1844, Jan. 22. Brooks, Sir William Cunliffe, Bart., M.A., M.P., *Bank,* 92, *King Street.*
1889, April 16. Brooks, Herbert S. *Slade House, Levenshulme.*
1860, Jan. 23. Brothers, Alfred, F.R.A.S. 14, *St. Ann's Square, Manchester.*
1886, April 6. Brown, Alfred, M.A., M.D. *Claremont, Higher Broughton,*
1893, April 18. Brown, F. E. *Hulme Grammar School, Manchester.*
1846, Jan. 27. Browne, Henry, M.A. (Glas.), M.R.C.S. (Lond.), M.D. (Lond.). *The Gables, Victoria Park.*
1889, Jan. 8. Brownell, T. W. *School Board Offices, Deansgate.*
1880, Oct. 15. Budenberg, C. F., M.Sc. *Bowdon Lane, Marple, Cheshire.*
1872, Nov. 12. Burghardt, Charles Anthony, Ph.D. 35, *Fountain Street.*

1854, April 18. Christie, Richard Copley, M.A., Chancellor of the Diocese, *Ribsden, Bagshot, Surrey.*
1841, April 30. Clay, Charles, M.D., Extr. L.R.C.P. (Lond.), M.R.C.S. (Edin.). *Tower Lodge, Poulton-le-Fylde, Lanc.*
1884, Nov. 4. Corbett, Joseph. *Town Hall, Salford.*
1853, Jan. 25. Cottam, Samuel, F.R.A.S., F.R. Hist. S., F.C.A. 49, *Spring Gardens.*
1893, Jan. 10. Chadwick, W. J. 2, *St. Mary's Street, City.*

Date of Election.

1859, Jan. 25. Coward, Edward. *Heaton Mersey, near Manchester.*

1876, April 18. Cunliffe, Robert Ellis. *Halton Bank, Pendleton.*

1871, Nov. 8. Dale, Richard Samuel, B.A. 1, *Chester Terrace, Chester Road.*

1853, April 19. Darbishire, Robert Dukinfield, B.A., F.S.A., F.G.S. *St. James' Square.*

1878, Nov. 26. Davis, Joseph. *Engineer's Offices, Lancashire and Yorkshire Railway, Hunt's Bank.*

1861, Dec. 10. Deane, William King. *Almondbury Place, Chester Road.*

1879, Mar. 18. Dent, Hastings Charles, F.L.S., F.R.G.S. 20, *Thurloe Square, London, S.W.*

1878, Feb. 8. Dixon, Harold B., M.A., F.R.S., Professor of Chemistry. *The Owens College.*

1892, April 26. Ewan, Thomas, B.Sc. *The Owens College.*

1883, Oct. 2. Faraday, Frederick James, F.L.S., F.S.S. *Ramsay Lodge, Slade Lane, Levenshulme.*

1886, Feb. 9. Gee, W. W. Haldane, B.Sc. *Technical School, Princess Street, Manchester.*

1881, Nov. 1. Greg, Arthur. *Eagley, near Bolton.*

1874, Nov. 3. Grimshaw, Harry, F.C.S. *Thornton View, Clayton.*

1888, Feb. 7. Grimshaw, William. *Stoneleigh, Sale.*

1892, Nov. 15. Groves, W. G. *The Larches, Alderley Edge.*

1875, Feb. 9. Gwyther, R. F., M.A., Fielden Lecturer in Mathematics. *The Owens College.*

1889, Nov. 12. Hall, Charles John, Mus. Doc. *Hawkesmoor, Southport.*

1890, Feb. 18. Harker, Thomas. *Brook House, Fallowfield.*

1862, Nov. 4. Hart, Peter. *Messrs Tennants & Co, Mill Street, Clayton N. Manchester.*

1873, Dec. 16. Heelis, James, 71, *Princess Street.*

1890, Mar. 4. Henderson, H. A. *Eastbourne House, Chorlton Road.*

1890, Nov. 4. Heenan, R. H., M.I.C.E., M.I.M.E. *Manor House, Wilmslow Park, Wilmslow.*

1889, Jan. 8. Heywood, Charles J. *Chaseley, Pendleton.*

1891, Nov. 3. Halkyard, Edward. *The Firs, Knutsford.*

1833, April 26. Heywood, James, F.R.S., F.G.S., F.S.A. 26, *Kensington Palace Gardens, London, W.*

1892, Nov. 29. Hicks, Rev. E. L., M.A., Canon of Manchester, Rector of St. Phillip's, Salford. 21, *Leaf Square, Pendleton.*

1884, Jan. 8. Hodgkinson, Alexander, M.B., B.Sc. 18, *St. John Street.*

1873, Dec. 2. Howorth, Sir Henry H., D.C.L., F.R.S., F.S.A., M.P. *Bentcliffe House, Eccles.*

1889, Oct. 15. Hoyle, W. E., M.A., Keeper of the Manchester Museum. 25, *Brunswick Road, Withington.*

Date of Election.	
1884, Jan. 8.	Hurst, Charles Herbert. *The Owens College, Manchester.*
1870, Nov. 1.	Johnson, William H., B.Sc. 26, *Lever Street.*
1878, Nov. 26.	Jones, Francis, F.R.S.E., F.C.S. *Grammar School.*
1890, Jan. 7.	Joseland, H. L., B.A. *The Grammar School.*
1891, Nov. 17.	Joyce, Samuel, Electrical Engineer. *Technical School, Princess Street, City.*
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1852, Jan. 27.	Kennedy, John Lawson. 47, *Mosley Street.*
1891, Dec. 1.	King, John Edward, M.A., High Master. *Manchester Grammar School.*
1890, Nov. 4.	Langdon, Maurice Julius, Ph.D. *Sunbury, Victoria Park.*
1863, Dec. 15.	Leake, Robert, M.P. *The Dales, Whitefield.*
1884, April 15.	Leach, Daniel John, Professor, M.D. *The Owens College.*
1850, April 30.	Leese Joseph. *Messrs. S. & E. Leese, Fylde Road Mill, Preston.*
1857, Jan. 27.	Longridge, Robert Bewick. *Yew Tree House, Tabley, Knutsford.*
1870, April 19.	Lowe, Charles, F.C.S. *Summerfield House, Reddish, Stockport.*
1866, Nov. 13.	McDougall, Arthur, B.Sc. *Fallowfield House, Fallowfield.*
1859, Jan. 25.	Maclure, John William, M.P., F.R.G.S. *Whalley Range.*
1875, Jan. 26.	Mann, John Dixon, M.D., F.R.C.P., Lond. 16, *St. John Street.*
1879, Dec. 2.	Marshall, Arthur Milnes, M.A., M.D., D.Sc., F.R.S., Professor of Zoology, Owens College. *The Owens College.*
1864, Nov. 1.	Mather, William, M.P. *Iron Works, Salford.*
1873, Mar. 18.	Melvill, James Cosmo, M.A. F.L.S., *Kersal Cottage, Prestwich.*
1879, Dec. 30.	Millar, John Bell, M.E., Lecturer in Engineering. *The Owens College.*
1881, Oct. 18.	Mond, Ludwig, F.C.S. *Winnington Hall, Northwich.*
1873, Mar. 4.	Nicholson, Francis, F.Z.S. 111, *Portland Street.*
1889, April 16.	Norbury, George. *Hillside, Prestwich Park, Prestwich*
1862, Dec. 30.	Ogden, Samuel. 10, *Mosley Street West.*
1884, April 15.	Okell, Samuel, F.R.A.S. *Overley, Langham Road, Bowdon.*
1844, April 30.	Ormerod, Henry Mere, F.G.S. 5, *Clarence Street.*
1892, Feb. 23.	Pankhurst, R. M., LL.D. (Lond.), Barrister-at-Law. *St. James Square, Manchester.*
1861, April 30.	Parlane, James. *Rusholme.*
1876, Nov. 28.	Parry, Thomas, F.S.S. *Grafton House, Ashton-under-Lyne.*

Date of Election.

1892, Nov. 15. Perkin, W. H., jun., Ph.D., F.R.S., Professor of Organic Chemistry. *The Owens College.*

1885, Nov. 17. Phillips, Henry Harcourt, F.C.S. 183, *Moss Lane East, Manchester.*

1854, Jan. 24. Pochin, Henry Davis, F.C.S. *Bodnant Hall, Conway.*

1854, Feb. 7. Ramsbottom, John, M.Inst. C.E. *Fernhill, Alderley Edge.*

1859, April 16. Ransome, Arthur, M.A., M.D., Cantab., F.R.S., M.R.C.S. 1, *St. Peter's Square.*

1888, Feb. 21. Rée, Alfred, Ph.D., F.C.S. 1, *Brighton Grove, Rusholme.*

1869, Nov. 16. Reynolds, Osborne, LL.D., M.A., F.R.S., M. Inst. C.E., Professor of Engineering, the Owens College. *Ladybarn Road, Fallowfield.*

1884, April 3. Rhodes, James, F.R.C.S. *Glossop.*

1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S.Ed., F.R.C.P. (London), *Ravenswood, Broughton Park.*

1864, Dec. 27. Robinson, John, M. Inst. C.E. *Westwood Hall, Leek.*

1858, Jan. 26. Roscoe, Sir Henry Enfield, B.A., LL.D., D.C.L., F.R.S., F.C.S., M.P. 10, *Bramham Gardens, Wetherby Road, London, S.W.*

1890, Jan. 21. Sacré, Howard C. *Breeze House, Higher Broughton.*

1851, April 29. Sandeman, Archibald, M.A. *Garry Cottage, near Perth.*

1893, Mar. 21. Schill, C. H. 117, *Portland Street, Manchester.*

1842, Jan. 25. Schunck, Edward, Ph.D., F.R.S., F.C.S. *Kersal.*

1873, Nov. 18. Schuster, Arthur, Ph.D., F.R.S., F.R.A.S. *The Owens College.*

1890, Jan. 21. Sidebottom, James Nasmyth. *Parkfield, Groby Place, Altrincham.*

1890, Nov. 4. Sidebotham, Edward, *Earlsdene, Bowdon.*

1886, April 6. Simon, Henry C. E. *Darwin House, Didsbury.*

1892, Nov. 29. Swindells, Rupert, M.I.C.E. *Wilton Villa, The Firs, Bowdon.*

1889, Oct. 15. Tatham, John F. W., M.D., M.A., Medical Officer of Health. *Town Hall, Manchester.*

1884, Mar. 18. Thompson, Alderman Joseph. *Riversdale, Wilmslow.*

1873, April 15. Thomson, William, F.R.S.E., F.C.S, F.I.C. *Royal Institution.*

1889, April 30. Thornber, Harry. *Rookfield Avenue, Sale.*

1860, April 17. Trapp, Samuel Clement. 88, *Mosley Street.*

1879, Dec. 30. Ward, Thomas. *Brookfield House, Northwich.*

1873, Nov. 18. Waters, Arthur William, F.G.S. *Villa Vecchia, Davos Dörfli, Switzerland.*

1859, Jan. 25. Wilde, Henry, F.R.S. *The Hurst, Alderley Edge.*

1859, April 19. Wilkinson, Thomas Read. *Manchester and Salford Bank, Mosley Street.*

Date of Election.	
1889, Nov. 12.	Willans, J. W. *Woodlands Park, Altrincham.*
1888, April 17.	Williams, E. Leader, M. Inst. C.E. *Spring Gardens, Manchester.*
1889, April 16.	Wilson, Thomas B. 37, *Arcade Chambers, St. Mary's Gate.*
1860, April 17.	Woolley, George Stephen. *Victoria Bridge, Salford.*
1863, Nov. 17.	Worthington, Samuel Barton, M. Inst. C.E. *Mill Bank, Bowdon.*
1865, Feb. 21.	Worthington, Thomas, F.R.I.B.A. 46, *Brown Street.*
1892, Nov. 15.	Weiss, F. E., B.Sc. Professor of Botany, the Owens College.

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore life members:

Brogden, Henry.
Johnson, William H., B.Sc.
Sandeman, Archibald, M.A.
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